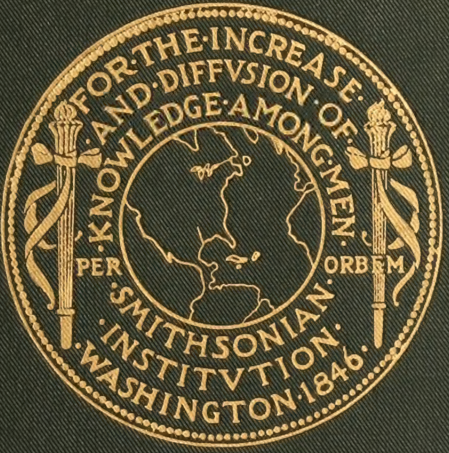

FOR·THE·INCREASE
·AND·DIFFVSION·OF·
KNOWLEDGE·AMONG·MEN·
PER
ORBEM
·SMITHSONIAN·
·INSTITVTION·
·WASHINGTON·1846·

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 100
VOLUME 3

CONTRIBUTIONS TO THE BIOLOGY OF THE PHILIPPINE ARCHIPELAGO AND ADJACENT REGIONS

STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS

By WALTER K. FISHER
Director of the Hopkins Marine Station of Stanford University, and
Curator of Invertebrate Zoology, California Academy of Sciences

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

BULLETIN OF THE UNITED STATES NATIONAL MUSEUM.

ADVERTISEMENT.

The scientific publications of the United States National Museum consist of two series, the *Proceedings* and the *Bulletins*.

The *Proceedings*, the first volume of which was issued in 1878, are intended primarily as a medium for the publication of original, and usually brief, papers based on the collections of the National Museum, presenting newly acquired facts in zoology, geology, and anthropology, including descriptions of new forms of animals, and revisions of limited groups. One or two volumes are issued annually and distributed to libraries and scientific organizations. A limited number of copies of each paper, in pamphlet form, is distributed to specialists and others interested in the different subjects as soon as printed. The dates of publication are also recorded in the tables of contents of the volumes.

The *Bulletins*, the first of which was issued in 1875, consist of a series of separate publications comprising chiefly monographs of large zoological groups and other general systematic treatises (occasionally in several volumes), faunal works, reports of expeditions, and catalogues of type-specimens, special collections, etc. The majority of the volumes are octavos, but a quarto size has been adopted in a few instances in which large plates were regarded as indispensable.

Since 1902 a series of octavo volumes containing papers relating to the botanical collections of the Museum, and known as the *Contributions from the National Herbarium*, has been published as bulletins.

The present work forms No. 100, volume 3 of the *Bulletin* series.

William deC. Ravenel,
Administrative Assistant to the Secretary,
In charge of the United States National Museum.

Washington, D. C., April 28, 1919.

TABLE OF CONTENTS.

Page.
Preface 1
Introduction 3
Distribution of species 5
1. Distribution of Philippine species 5
2. Analysis of species taken only in Philippine waters 10
3. Relationships of Philippine fauna 17
4. Analysis of species taken outside of Philippine waters 19
5. Relationships of Celebes-Moluccan species 21
List of starfishes recorded from Celebes and the Moluccas, including Bouro, Amboina, and Ceram 23
List of dredging stations at which starfishes were secured, with the species taken at each 28
Descriptions of species 35
Family Porcellanasteridae 35
Genus Sidonaster 35
Sidonaster vaneyi 35
psilonotus 37
Genus Benthogenia 39
Benthogenia cribellosa 39
Family Goniopectinidae 43
Genus Ctenodiscus 44
Ctenodiscus orientalis 44
Genus Goniopecten 47
Goniopecten asiaticus 47
Genus Prionaster 50
Prionaster analogus 50
gracilis 55
megaloplax 56
Family Astropectinidae 59
Genus Craspidaster 60
Craspidaster hesperus 60
Genus Astropecten 62
Astropecten polyacanthus 63
phragmorus 65
mindanensis 67
vappa inaequalis 69
velitaris 70
granulatus 73
monacanthus 74
eucnemis 75
eremicus 79
luzonicus 82
tenellus 84
pedicellaris 87
Genus Ctenopleura 90
Ctenopleura astropectinides 91

Family Astropectinidae—Continued. Page.
Genus Ctenophoraster 95
Ctenophoraster diploctenius 95
Genus Psilaster 100
Psilaster gotoi 100
robustus 103
species 106
Genus Astromesites 107
Astromesites compactus 107
Genus Persephonaster 111
Persephonaster euryactis 112
euryactis brevispinus 115
anchistus 117
luzonicus 118
tenuis 121
multicinctus 123
suluensis 125
oediplax 127
habrogenys 131
monostoechus 134
Genus Tritonaster 136
Tritonaster evorus 136
Genus Anthosticte 140
Anthosticte aulophora 140
Genus Dipsacaster 145
Dipsacaster nesiotes 145
imperialis 146
diaphorus 152
Genus Patagiaster 154
Patagiaster sphaerioplax 154
Genus Koremaster 157
Koremaster evaulus 157
evaulus spiculatus 161
Family Luidiidae 163
Genus Luidia 163
Luidia longispina 164
prionota 164
orientalis 166
maculata 168
savignyi 170
aspera 171
avicularia 172
gymnochora 175
Family Archasteridae 180
Genus Archaster 180
Archaster typicus 180
angulatus 181
Family Benthopectinidae 182
Genus Pectinaster 182
Pectinaster mimicus 182
mimicus palawanensis 185
hylacanthus 187

Family Benthopectinidae—Continued.

Page.

Genus Cheiraster 190
Cheiraster inops 191
niasicus 192
gazellae 196
diomedeae 200
ludwigi 203
triplacanthus 205
Genus Benthopecten 208
Benthopecten moluccanus 208
polyctenius 211
styracius 213
Family Radiasteridae 215
Genus Radiaster 217
Radiaster notabilis 217
Family Goniasteridae 220
Genus Pseudarchaster 220
Pseudarchaster jordani 220
oligoporus 222
Genus Aphroditaster 225
Aphroditaster microceramus 225
Genus Paragonaster 228
Paragonaster ctenipes hypacanthus 228
stenostichus 232
Genus Perissogonaster 235
Perissogonaster insignis 236
Genus Rosaster 240
Rosaster nannus 244
mamillatus 247
mimicus 250
symbolicus 253
Genus Mediaster 255
Mediaster ornatus 256
Genus Ceramaster 257
Ceramaster smithi 257
Genus Nymphaster 261
Nymphaster euryplax 264
dyscritus 266
mucronatus 269
leptodomus 272
moluccanus 274
arthrocnemis 277
meseres 280
habrotatus 282
atopus 285
Genus Sphaeriodiscus 287
Sphaeriodiscus scotocryptus 287
Genus Peltaster 290
Pelaster cycloplax 290
Genus Pontioceramus 294
Pontioceramus grandis 294

Family Goniasteridae—Continued. Page.
Genus Lithosoma 298
Lithosoma actinometra 298
penichra 301
Genus Iconaster 303
Iconaster longimanus 303
perierctus 306
Genus Astroceramus 309
Astroceramus lionotus 310
sphaeriostictus 313
Genus Calliaster 316
Calliaster corynetes 316
Genus Astrothauma 320
Astrothauma euphylacteum 320
Genus Goniodiscaster 324
Goniodiscaster forficulatus 324
Genus Stellaster 326
Stellaster incei 326
Genus Anthenoides 328
Anthenoides cristatus 329
granulosus 333
lithosorus 336
rugulosus 338
Genus Atelorias 342
Atelorias anacanthus 343
Family Oreasteridae 346
Genus Oreaster 346
Oreaster nodosus 346
alveolatus 348
Genus Pentaceropsis 350
Pentaceropsis tyloderma 350
Genus Asterodiscus 354
Asterodiscus elegans 355
helonotus 357
Genus Culcita 360
Culcita novae-guineae 360
novae-guineae, young 361
novae-guineae plana 361
Genus Halityle 362
Halityle regularis 362
Genus Choriaster 367
Choriaster granulatus 367
Family Linckiidae 367
Genus Dissogenes 367
Dissogenes styracia 368
Genus Ferdina 370
Ferdina glyptodisca 370
Genus Fromia 373
Fromia japonica 373
eusticha 375
hemiopla 377
milleporella 378

Family Linckiidae—Continued.

Page.

- Genus Nardoa 378
  - Nardoa lemonnieri 382
    - squamulosa 383
    - semiregularis 383
    - tuberculata 384
    - frianti 385
    - tumulosa 386
- Genus Ophidiaster 388
  - Ophidiaster fuscus 388
    - trychnus 390
    - tuberifer 393
    - dubiosus 394
- Genus Leiaster 396
  - Leiaster analogus 396
- Genus Bunaster 398
  - Bunaster lithodes 398
- Genus Linckia 400
  - Linckia laevigata 400
    - multifora 400
    - guildingii 401

Family Ganeriidae 401

- Genus Tarachaster 401
  - Tarachaster tenuis 402

Family Metrodiridae 405

- Genus Metrodira 405
  - Metrodira subulata 406

Family Poraniidae 407

- Genus Marginaster 407
  - Marginaster paucispinus 407

Family Asterinidae 409

- Genus Asterina 409
  - Asterina cepheus 411
    - coronata cristata 411
    - coronata euerces 414
- Genus Patiriella 416
  - Patiriella exigua 416
- Genus Asterinopsis 417
  - Asterinopsis pedicellaris 417
- Genus Paranepanthia 419
  - Paranepanthia platydisca 420
- Genus Nepanthia 422
  - Nepanthia maculata 422
    - joubini 423
- Genus Anseropoda 424
  - Anseropoda macropora 424
    - species 425

Family Echinasteridae 426

- Genus Echinaster 426
  - Echinaster callosus 428
    - stereosomus 430
- Genus Othilia 432
  - Othilia purpurea 432

Family Echinasteridae—Continued.

	Page.
Genus Henricia	435
Henricia densispina	436
microplax	437
arcystata	439
Family Acanthasteridae	441
Genus Acanthaster	441
Acanthaster planci	441
brevispinus	442
Family Solasteridae	444
Genus Solaster	444
Solaster tropicus	444
Genus Crossaster	447
Crossaster scotophilus	447
Genus Lophaster	449
Lophaster suluensis	449
Genus Xenorias	451
Xenorias polyctenius	451
Family Myxasteridae	454
Genus Myxaster	454
Myxaster medusa	454
Family Pterasteridae	456
Genus Pteraster	456
Pteraster corynetes	456
obesus myonotus	458
Genus Retaster	460
Retaster insignis	460
Genus Diplopteraster	462
Diplopteraster multipes patagiatus	462
Genus Hymenaster	463
Hymenaster rhodopeplus	463
bartschi	465
Genus Hymenasterides	467
Hymenasterides zenognathus	468
Family Zoroasteridae	470
Genus Zoroaster	471
Zoroaster ophiactis	473
microporus	475
carinatus philippinensis	477
Genus Cnemidaster	480
Cnemidaster wyvillii	480
Genus Pholidaster	484
Pholidaster squamatus	484
Genus Bythiolophus	484
Bythiolophus acanthinus	485
Family Asteriidae	487
Genus Distolasterias	487
Distolasterias euplecta	487
hypacantha	487
Genus Tarsaster	490
Tarsaster distichopus	490

Page.
Family Pedicellasteridae 492
  Genus Coronaster 494
    Coronaster volsellatus 496
      halicepus 497
  Genus Pedicellaster 499
    Pedicellaster chirophorus 499
      species 501
Family Brisingidae 501
  Genus Odinia 505
    Odinia penichra 505
      magister 507
  Genus Brisinga 509
    Brisinga trachydisca 510
  Genus Craterobrisinga 512
    Craterobrisinga eucoryne 514
      analoga 516
  Genus Brisingenes 517
    Brisingenes mimica 518
      anchista 521
  Genus Brisingella 523
    Brisingella fragilis 524
  Genus Astrostephane 525
    Astrostephane moluccana 526
      acanthogenys 528
  Genus Stegnobrisinga 530
    Stegnobrisinga placoderma 531
  Genus Freyellaster 537
    Freyellaster spatulifer 538
Bibliography 541
Explanation of Plates 547
Index 703

STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

By Walter K. Fisher,

Director of the Hopkins Marine Station of Stanford University and Curator of Invertebrate Zoology, California Academy of Sciences.

PREFACE.

The following report is based upon an extensive collection of sea stars made by the United States Fisheries steamer *Albatross* between December, 1907, and December, 1910, in the region of the Philippine Islands, Celebes, and Molucca Islands.

The Philippine cruise of the *Albatross* was under the supervision of Dr. Hugh M. Smith, then deputy commissioner, now commissioner, of fisheries, to whom I am indebted not only for the privilege of describing the starfish material, but also for his constant cooperation during the progress of the work.

The *Albatross* occupied 576 dredging stations, at 224 of which starfishes were obtained, in addition to numerous shore stations. There is appended to the introduction a list of dredging stations, with data, and the species obtained at each station.

The naturalists of the *Albatross* deserve credit for the excellent preservation of the specimens—a result not always easy to achieve in the unfavorable conditions of the Tropics.

In addition to the *Albatross* material, two new forms are described from the collection of the Museum of Comparative Zoology, and a number of specimens have been listed which were collected in the Philippines by the late Dr. Edgar A. Mearns, U. S. Army.

One hundred and ninety species and subspecies of sea stars were brought back by the *Albatross*, which with those just mentioned make a total of 192 described or listed in this report. One hundred and thirty-four species and subspecies are believed to be new. Most of them have been described already in preliminary papers (see Bibliography). A total of 90 species were not met with outside of the Philippine Islands and the basin of the Sulu Sea, of which all but four are new. One hundred and one species are either wider ranging forms, or else were collected only in the China Sea, in Celebes waters, or among the Molucca Islands. Of these, 47 are new species. Fifty-nine, out of 101 species, occur in the Philippines (8 new), making a total of 149 species for the group, of which only 55 had been described prior to the *Albatross* expedition. A majority of the 55 are here recorded for the first time from the Philippines.

Eighteen new generic types were discovered by the *Albatross* expedition, while new species have made desirable the segregation of six additional genera and subgenera.

The new generic types are:

Benthogenia,
Astromesites,
Anthosticte,
Koremaster,
Perissogonaster,
Pontioceramus,
Lithosoma,
Astrothauma,
Atelorias,
Halityle,
Dissogenes,
Tarachaster,
Xenorias,
Hymenasterides,
Bythiolophus,
Brisingenes,
Astrostephane,
Stegnobrisinga.

The other new genera and subgenera are:

Ctenopleura, near *Astropecten*.
Paranepanthia, near *Nepanthia* and *Asterinopsis*.
Glyphodiscus, new subgenus of *Iconaster*.
Freyellaster, near *Freyella*.
Brisingella, near *Brisinga*.
Craterobrisinga, near *Brisinga*.

During the preparation of this report I have had occasion to draw rather freely upon the collection of the United States National Museum for comparative material. It is a great pleasure to record the liberal cooperation of the Museum authorities and in particular that of Dr. Paul Bartsch and Mr. Austin H. Clark. The collection of the Museum of Comparative Zoology of Cambridge is a treasure house for the systematist, and its facilities have always been most agreeably placed at my disposal, both during visits and by the loan of specimens, for which I am indebted to Dr. Hubert Lyman Clark and Mr. Samuel Henshaw. The holotypes of *Asterina coronata cristata* and *Bunaster lithodes* are in the collection of this museum.

During a brief visit to London I was able to examine a number of types in the British Museum, especially some of J. E. Gray's from Migupou, and for this courtesy I am indebted to Prof. F. Jeffrey Bell. Similarly Professor Joubin gave me access to the starfish collection of the Museum d'Histoire Naturelle of Paris, and Doctor Horst to that of the Leyden Museum, and to these gentlemen my best thanks are tendered. Nor should I omit a conference with my genial friend, Dr. Réne Koehler, of the University of Lyon, the leading European authority on Asteroidea and Ophiuroidea.

As already stated most of the new species brought back by the *Albatross* have been briefly described. These are contained in papers registered in the bibliography as Fisher 1911*c*, 1913*a*, 1913*c*, 1916*b*, 1917*a*, 1917*b*, while notes bearing directly upon Philippine material are contained in 1916*a*, 1917*a*, 1917*f*, and 1918. Keys to orders, families, and genera will be found in 1911*d* and 1906.

The bulk of the photographs illustrating this report were prepared under the direction of Mr. T. W. Smillie, of the United States National Museum, from specimens arranged by the writer. The drawings illustrating structural details, and the photographic figures of the Asteriidae and Brisingidae were made by the writer.

INTRODUCTION.

References to the starfishes of the Philippines are found in scattered papers dealing with larger areas or in such general works as Gray's Synopsis of the Genera and Species of the Class Hypostoma, Perrier's Révision des Stellérides, and Sladen's *Challenger* Asteroidea. There are no special papers dealing with the Philippine starfish fauna, with the single exception of that by Bell On the Echinoderms collected during the Voyage of H. M. S. *Penguin* and H. M. S. *Egeria*, when surveying Macclesfield Bank. This bank is about 300 miles west of Lingayen Gulf, Luzon, about midway between Luzon and Annam, and is outside of Philippine waters as classified in this report.

J. E. Gray[1] (1840) in his well-known paper assigns the following new species to Luzon:

Randasia luzonica.
Nardoa tuberculata.
Othilia luzonica.

The following are from Migupou,[2] probably a Philippine locality:

Metrodira subulata.
Tamaria fusca (=*Ophidiaster fuscus*).
Nepanthia maculata.

In 1844 Müller and Troschel describe in Wiegmann's Archiv[3] *Linckia pusilla* (=*Ophidiaster pusillus*) from the Philippine Islands.

In 1847 Gray describes *Ilosia spinulosa* (=*Anthenea spinulosa*) from the Indian Ocean and Philippine Islands.

Von Martens (1866) mentions the following species:

Echinaster fallax Müller and Troschel=*Othilia luzonica* Gray=*O. purpurea* Gray, Luzon.

Echinaster solaris Schmidel=*Acanthaster planci* (Linnaeus), Zamboanga, Mindanao, reef.

Linckia miliaris (Linck)=*L. laevigata* (Linnaeus), Zamboanga.

---

[1] See Bibliography, p. 541, for titles.

[2] Mr. Alvin Seale, of the Museum of Comparative Zoology, tells me that he has sailed past a Migupou Point, but does not recall now whether it is on Luzon or on Mindanao. I have not been able to find it on available maps. Possibly this is the locality to which Gray refers.

[3] Jahrgang 10, vol. 1, p. 180.

Asterina gibbosa (Pennant), *var.*=*A. cephus* ?, "Philippines, im Berliner Museum."

Asterina pentagona (Müller and Troschel)=*Patiriella exigua* (Lamarck), Provinz Albay auf Luzon.

Luidia maculata Müller and Troschel, Manila Bay.

The next year in a short paper the following species are ascribed to the Philippines:

Echinaster solaris Schmidel=*Acanthaster planci* (Linnaeus), described; Zamboanga, Mindanao.

Gymnasteria carinifera (Lamarck)=*Asterope carinifera*, Zamboanga, Mindanao.

In 1875, Perrier in the Révision described *Scytaster obtusus* (=*Nardoa obtusa*) from the Philippines. The type, which I have examined, is a young specimen. He also records the following species:

Acanthaster echinites=*A. planci.*

Echinaster fallax=*Othilia purpurea.*

Ophidiaster pusillus.

Linckia miliaris=*L. laevigata.*

Scytaster tuberculatus=*Nardoa tuberculata.*

Pentagonaster spinulosus=*Anthenea spinulosa.*

Pentaceros obtusatus=*Pentaceropsis obtusata.*

Asterina cepheus.

Pteraster cribrosus=*Retaster insignis.*

Sladen (1889) described the following new Philippine species from the *Challenger* collections:

Astropecten imbellis, off Tablas Island, 100 fathoms.

Astropecten monacanthus, east of Panay, 20 fathoms.

Dytaster inermis, Celebes Sea, between Celebes and Mindanao, 2,150 fathoms.

Luidia aspera, off Zamboanga, Mindanao, 10 fathoms; off Tablas Island, 100 fathoms.

Luidia longispina, east of Panay Island, 20 fathoms.

Pontaster trullipes, west of Luzon, 1,050 fathoms.

Nymphaster symbolicus, off Tablas Island, 100 fathoms.

Leptogonaster cristatus, off Tablas Island, 100 fathoms.

Pentaceros productus, var. *tuberata*, off Zamboanga, 10 fathoms; off Malanipa Island, 10 fathoms.

Pholidaster squamatus, off Tablas Island, 100 fathoms.

Asterias (*Stolasterias*) *volsellata*, near Cebu, 95 fathoms.

Freyella echinata, Celebes Sea, between Celebes and Mindanao, 2,150 fathoms; west of Luzon, 1,050 fathoms.

He also recorded the following species collected by the *Challenger:*

Craspidaster hesperus, east of Panay Island, 20 fathoms.

Archaster typicus, east of Zamboanga, 250 fathoms; off Zamboanga, 10 fathoms; off Cebu, reefs.

Stellaster incei, off east point of Panay, 18 fathoms.

Asterodiscus elegans, off Zamboanga, 10 fathoms.

Pentaceros turritus=*Oreaster nodosus* (Linnaeus), off Zamboanga, 10 fathoms; off Cebu, reefs; off Malanipa Island, 10 fathoms.

Pentaceropsis obtusata, off Cebu, reefs.

Culcita novae-guineae, off Cebu, reefs; off Malanipa Island, 10 fathoms.

Choriaster granulatus, off Zamboanga, 10 fathoms.

Nardoa tuberculata, off Zamboanga, 10 fathoms; off Cebu, reefs.

Linckia miliaris=*L. laevigata*, off Cebu, reefs.

Asterina cepheus, off Zamboanga, 10 fathoms.

Acanthaster echinites=*A. planci*, off Cebu, reefs.

In the article, already mentioned, on the Echinoderms of Macclesfield Bank, Professor Bell (1894) lists the following starfishes, those marked with an asterisk being new:

	Fathoms.		Fathoms.
Archaster typicus	23–50	**Chaetaster moorei*	36–40
**Archaster tenuis*	35–41	*Asterina cepheus*	17–30
Astropecten polyacanthus	30–41	*Fromia milleporella*	22–40
Luidia? aspera (young)	20–35	*Leiaster? leachi* (young)	41–44
Luidia forficifer	30–40	*Leiaster? speciosus* (young)	30–46
Luidia hardwickii	31–37	*Nardoa tuberculata*	30–46
Luidia longispina	30–45	*Rhipidaster? vannipes*	32
Luidia maculata (young)	30–41	*Mithrodia clavigera*	41–44
Goniodiscus rugosus (young)	45	*Echinaster purpureus*	29–40
**Culcita* (young), new species	40–50	*Asterias volsellata*	32
**Patiria briareus*	30–45		

DISTRIBUTION OF SPECIES.

I. Distribution of Philippine Species.

Of the 149 species found in the Philippine Archipelago, 90 were not met with outside the group. The remaining 59 species range outside the islands and included seas and are analyzed in the following lists *a* to *k*:

(*a*) Species common to the Red Sea, Indian Ocean, Philippines, Eastern Archipelago, and parts of the central and western Pacific:

Astropecten polyacanthus.
Fromia milleporella.
Linckia laevigata.
Linckia multifora.
Asterina cepheus.
Othilia purpurea.
Acanthaster planci.

(*b*) Species common to the Red Sea, Indian Ocean, and Philippines, but not ranging into the Pacific:

Astropecten monacanthus.
Luidia savignyi.

(*c*) Species common to the Indian Ocean (including the Bay of Bengal and Arabian Sea), Eastern Archipelago (including the Philippines) and parts of the Pacific:

Craspidaster hesperus.
Astropecten velitaris.
Luidia maculata.
Archaster typicus.
Archaster angulatus.
Cheiraster inops.
Mediaster ornatus.
Pseudarchaster jordani.
Stellaster incei.
Oreaster nodosus.
Culcita novae-guineae.
Culcita n. plana.
Linckia guildingi.
Metrodira subulata.
Patiriella exigua.
Echinaster callosus.

With the exception of *Cheiraster inops*, *Pseudarchaster jordani*, and *Mediaster ornatus*, which occur below the 200-fathom line, the species listed under *a*, *b*, and *c* are littoral and shallow-water species, 22 in number.

(*d*) Species common to the Philippines and Bay of Bengal:

Goniodiscaster forficulatus.
Nardoa lemonnieri.
Nardoa squamulosa.
Nardoa frianti.
Ophidiaster tuberifer (to Arafura Sea).
Ophidiaster dubiosus.

These are all littoral or shallow-water forms, none ranging to the 100-fathom line.

(*e*) Species common to the Philippines and Arabian Sea:

Sidonaster vaneyi (733–833 fathoms).

(*f*) Philippine species ranging into the China Sea:

Persephonaster anchistus.
Asterodiscus elegans.
Nepanthia joubini.

(*g*) Philippine species ranging into the western Pacific:

Luidia aspera (to Admiralty Islands).
Oreaster alveolatus (to New Caledonia).
Retaster insignis (lists i, j).

(*h*) Philippine species extending to Japan:

Choriaster granulatus (to New Zealand and western Pacific).
Fromia japonica (to Java, Banda, and Arafura Seas).
Henricia densispina (Straits of Korea).

(*i*) Species common to the Philippines and Celebes (*c*) or Moluccas (*m*):

1. Littoral forms:

Iconaster longimanus (to Java, Banda, and Arafura Seas).
Nardoa semiregularis (into Java Sea).
Nardoa tuberculata (to Java, Banda, and Arafura Seas).
Ophidiaster fuscus (to northwest Australia and Arafura Sea).

2. Deep-water species:

Ctenodiscus orientalis, *m. c.*
Pectinaster hylacanthus, *m.*
Cheiraster niasicus, *c. m.*
Atelorias anacanthus, *c.*
Retaster insignis (lists g, j).
Hymenasterides zenognathus, *m.*
Zoroaster ophiactis, *c.*
Cnemidaster wyvillii, *c.* (to Arafura Sea).
Coronaster halicepus, *m.*
Stegnobrisinga placoderma, *c.*

(*j*) Philippine species extending into the Banda and Arafura Seas:

Astropecten granulatus.
Rosaster symbolicus.
Iconaster longimanus.
Nardoa tuberculata.
Fromia japonica (to Japan).
Ophidiaster tuberifer (to Bay of Bengal).
Ophidiaster fuscus (to northwest Australia).
Nepanthia maculata.
Retaster insignis (lists *g*, *i*).
Cnemidaster wyvillii.

(*k*) Species common to Philippine and Hawaiian Islands:

Cheiraster inops (to Indian Ocean, list *c*).
Pseudarchaster jordani (Borneo, and Indian Ocean, list *c*).
Mediaster ornatus (to Arabian Sea, list *c*).
Distolasterias euplecta.
Brisingella fragilis.

(*l*) Bathymetric distribution of species of lists *a* to *k* occurring below the 100 fathom line:

1. From between 99 and 200 fathoms:

Astropecten granulatus.
Persephonaster anchistus.
Luidia aspera.
Rosaster symbolicus.
Henricia densispina.
Coronaster halicepus.
Distolasterias euplecta.

2. From between 200 and 300 fathoms:

Cheiraster inops.
Cheiraster niasicus.
Henricia densispina.
Hymenasterides zenognathus.
Coronaster halicepus.
Brisingella fragilis.

3. From between 300 to 500 fathoms:

Ctenodiscus orientalis.
Pectinaster hylacanthus.
Cheiraster inops.
Pseudarchaster jordani.
Henricia densispina.
Brisingella fragilis.

4. From between 500 and 700 fathoms:

Cheiraster inops.
Atelorias anacanthus.
Zoroaster ophiactis.
Stegnobrisinga placoderma.

5. From between 700 and 1,100 fathoms:

Pseudarchaster jordani.	*Zoroaster ophiactis.*
	Cnemidaster wyvillii.

Summary.—(Species taken only among the Philippine Islands, 90.) Species ranging well into the China Sea (*f*), 3. Additional forms ranging into western Pacific (*g*), 3.

Additional forms ranging to—

Bay of Bengal (*d*), 6;
Arabian Sea (*e*), 1;
Celebes or Moluccas (*i*), 14;
Banda and Arafura Seas (*j*), 10, but only 4 not in lists *d* and *i*.

Species ranging to—

Hawaii (*k*), 5.
Japan (*h*), 3.

Wide-ranging species, Indian Ocean, Eastern Archipelago, and Pacific (*c*), 16.

Additional forms ranging into Red Sea (*a*), 7.

Additional forms ranging into Red Sea but not into the Pacific (*b*), 2.

In the following table all species listed in the report are enumerated, except 90, which were met with only in the Philippine Archipelago. For analysis of those found only in Moluccan and Celebes waters see section IV.

Distribution of Species other than those found only among the Philippine Islands.

	Red Sea.	Arabian Sea.	Bay of Bengal.	Indian Ocean.	China Sea.	Japan.	Philippine Is.	Celebes and Moluccas.	Java Sea.	Banda and Arafura Sea.	Pacific Ocean.	Range in fathoms.						
												0-100.	100-200.	200-300.	300-500.	500-700.	700-900.	900-1100.
Sidonaster vaneyi		×					×									×	×	
Ctenodiscus orientalis							×	×							×	×	×	
Prionaster megaloplax								M[a]						×				
Craspidaster hesperus			×		×	×	×		×	×		×						
Astropecten polyacanthus	×		×	×	×	×	×	×	×	×	×	×						
Astropecten velitaris				×	×		×			×	×	×						
Astropecten granulatus							×			×		×	×					
Astropecten monacanthus	×		×				×					×						
Psilaster robustus								M								×		
Persephonaster anchistus					×			×					×					
Persephonaster tenuis					×								×					
Persephonaster multicinctus								C								×		
Persephonaster monostoechus								C									×	
Dipsacaster nesiotes								M			×[b]			×				
Koremaster evaulus								C									×	
Luidia orientalis					×									×				
Luidia maculata			×	×	×	×	×		×	×		×						
Luidia savignyi	×		×	×			×					×						
Luidia aspera							×				×[c]	×	×					
Archaster typicus				×			×	×	×	×	×	×						

[a] The letters M and C represent Moluccas and Celebes, respectively.
[b] Hawaiian Islands.
[c] Admiralty Islands.

DISTRIBUTION OF SPECIES OTHER THAN THOSE FOUND ONLY AMONG THE PHILIPPINE ISLANDS—Continued.

	Red Sea.	Arabian Sea.	Bay of Bengal.	Indian Ocean.	China Sea.	Japan.	Philippine Is.	Celebes and Moluccas.	Java Sea.	Banda and Arafura Sea.	Pacific Ocean.	Range in fathoms.						
												0–100.	100–200.	200–300.	300–500.	500–700.	700–900.	900–1100.
Archaster angulatus				×			×		×	×	×	×						
Pectinaster mimicus		?						×		×							×	×
Pectinaster hylacanthus							×	×							×			
Cheiraster inops				×			×				×[b]			×	×	×		
Cheiraster niasicus							×	×						×	×			
Cheiraster gazellae				×			×							×				
Cheiraster ludwigi								×[d]								×		
Cheiraster triplacanthus								C								×		
Benthopecten moluccanus								×							×			
Benthopecten polyctenius								C									×	
Benthopecten styracius								C									×	
Radiaster notabilis								×								×		
Pseudarchaster jordani				×				M[e]			×[a]				×			×
Pseudarchaster oligoporus								C										×
Aphroditaster microceramus								C								×		
Rosaster symbolicus							×			×		×	×					
Mediaster ornatus		×					×				×[a]			×	×			
Nymphaster moluccanus								M						×				
Nymphaster arthrocnemis								C								×		
Icoraster longimanus							×		×	×		×						
Goniodiscaster forficulatus			×				×					×						
Stellaster incei			×	×	×		×		×	×	×[f]	×						
Anthenoides granulosus								M						×				
Anthenoides lithosorus					×									×				
Atelorias anacanthus							×	C								×		
Oreaster nodosus				×			×	×	×	×	×	×						
Oreaster alveolatus							×				×[g]	×						
Asterodiscus elegans					?		×					×						
Culcita novaeguineae				×		×	×	×	×	×	×	×						
Culcita novaeguineae plana				×			×	?	×	×	×	×						
Choriaster granulatus						×	×	C			×	×						
Dissogenes styracia								M					×					
Ferdina glyptodisca								C				×						
Fromia japonica			?			×	×		×	×		×						
Fromia milleporella	×			×		×	×	×	×	×	×	×						
Nardoa lemonnieri			×				×					×						
Nardoa squamulosa			×				×					×						
Nardoa semiregularis							×	M	×			×						
Nardoa tuberculata							×	×	×	×		×						
Nardoa frianti			×				×					×						
Ophidiaster fuscus				×			×	C				×						
Ophidiaster tuberifer			×				×			×		×						
Ophidiaster dubiosus			×				×					×						
Linckia laevigata	×	×	×	×			×	×	×	×	×	×						
Linckia multifora	×			×			×	×		×	×	×						
Linckia guildingii [h]		×	×	×			×			×	×	×						
Metrodira subulata			×	×[i]	×[k]		×			×	×[j]	×						
Marginaster paucispinus					×								×					
Nepanthia maculata							×			×		×						
Nepanthia joubini					×		×					×						
Paranepanthia platydisca								C						×				
Asterina cepheus	×	×	×	×			×		×	×	×	×						
Asterina coronata cristata										×	×	×						
Patiriella exigua		×	×	×			×	×	×	×	×[l]	×						
Echinaster callosus			×				×	C			×[m]	×						
Othilia purpurea	×		×	×			×	×		×	×[n]	×						
Henricia densispina						×[o]	×						×	×	×			
Acanthaster planci	×	×	×	×	?	×[p]	×	×	?	×	×	×						

[a] The letters M and C represent Moluccas and Celebes, respectively.
[b] Hawaiian Islands.
[c] Admiralty Islands.
[d] Flores Sea.
[e] Also Borneo.
[f] Australia.
[g] New Caledonia.
[h] Also in West Indies; Cape Verde Is.
[i] Ceylon and northwest Australia.
[j] New Zealand; northeast Australia.
[k] Macclesfield Bank.
[l] East Australia.
[m] Solomon Islands.
[n] New Zealand, eastern Australia.
[o] Strait of Korea.
[p] Ryukyu Islands.

DISTRIBUTION OF SPECIES OTHER THAN THOSE FOUND ONLY AMONG THE PHILIPPINE ISLANDS—Continued.

	Red Sea.	Arabian Sea.	Bay of Bengal.	Indian Ocean.	China Sea.	Japan.	Philippine Is.	Celebes and Moluccas.	Java Sea.	Banda and Arafura Sea.	Pacific Ocean.	Range in fathoms.						
												0-100.	100-200.	200-300.	300-500.	500-700.	700-900.	900-1100.
Solaster tropicus								×							×		×	
Crossaster scotophilus								C								×		
Xenorias polyctenius								M						×				
Myxaster medusa								C								×		
Pteraster corynetes								M						×				
Retaster insignis							×	×		×	×	×						
Diplopteraster m. patagiatus								C							×			
Hymenaster rhodopeplus								C									×	
Hymenasterides zenognathus							×	×						×				
Zoroaster ophiactis							×	×								×	×	
Zoroaster microporus								M								×		
Cnemidaster wyvillii							×	C		×							×	×
Bythiolophus acanthinus								C								×		
Distolasterias euplecta							×				×[a]	×	×					
Tarsaster distichopus								C							×			
Coronaster halicepus							×	M					×	×				
Pedicellaster chirophorus								C							×			
Freyellaster spatulifer								C									×	
Brisingenes mimica								C								×		
Brisingenes anchista								C								×		
Astrostephane moluccana								×						×		×		
Brisingella fragilis							×				×[a]			×	×			
Stegnobrisinga placoderma							×	C								×		

[a] Hawaiian Islands.

II. ANALYSIS OF SPECIES TAKEN ONLY IN PHILIPPINE WATERS.

(*a*) Species taken only in Luzon waters.

1. From between 100 and 200 fathoms:

Astropecten luzonicus.
Ctenophoraster diploctenius.
Astromesites compactus.
Persephonaster euryactis.
Paragonaster stenostichus.
Peltaster cycloplax.
Lithosoma actinometra.
Calliaster corynetes.
Astrostephane acanthogenys.

2. From between 200 and 300 fathoms:

Astropecten luzonicus.
Persephonaster luzonicus.
Tritonaster evorus.
Rosaster mimicus.
Nymphaster mucronatus.

3. From between 300 and 500 fathoms:

Psilaster gotoi.
Dipsacaster imperialis.
Nymphaster meseres.

(*b*) Species taken in the vicinity of Luzon and also in the interisland waters north of Mindanao and Surigao Seas:

Coronaster volsellatus (95–165).
Paragonaster ctenipes hypacanthus (114–172).
Pontioceramus grandis (114–200).
Persephonaster oediplax (283–604).

(*c*) Species from interisland waters south of Marinduque and north of Mindanao and Surigao Seas:

1. From less than 100 fathoms:
   Patagiaster sphaerioplax.
   Rosaster mamillatus.
   Ophidiaster trychnus.
   Bunaster lithodes (littoral).
   Asterinopsis pedicellaris.
   Distolasterias hypacantha.
2. From between 100 and 200 fathoms:
   Goniopecten asiaticus.
   Anthosticte aulophora.
   Luidia avicularia.
   Astrothauma euphylacteum.
   Pholidaster squamatus.
   Distolasterias hypacantha.
   Odinia penichra.
3. From between 200 and 300 fathoms:
   Luidia gymnochora, *Nymphaster leptodomus*, *Henricia arcystata.*
4. From between 500 and 700 fathoms:
   Ceramaster smithi.
   Henricia arcystata (to 530).
5. From between 700 and 900 fathoms:
   Koremaster evaulus spiculatus.
6. Depth not recorded:
   Odinia magister.

(*d*) Species taken only in the Mindanao and Surigao Seas and adjacent bays:

1. Less than 100 fathoms:
   Pentaceropsis tyloderma, *Echinaster stereosomus*, *Pteraster obesus myonotus.*
2. From between 100 and 200 fathoms:
   Nymphaster euryplax.
   Tarachaster tenuis.
   Henricia microplax.
3. From between 200 and 300 fathoms:
   Nymphaster dyscritus, *Pteraster obesus myonotus.*
4. From between 300 and 500:
   Cheiraster diomedeae.

(*e*) Species taken only in the basin of the Sulu Sea and adjacent Mindanao Sea; those marked with a star are from the Sulu Basin only:

1. From less than 100 fathoms:
    - *Astropecten vappa inaequalis.**
    - *Rosaster nannus.**
    - *Iconaster perierctus.**
    - *Asterodiscus helonotus.**
    - *Halityle regularis.**
    - *Fromia eusticha.**
    - *Fromia hemiopla.**
    - *Nardoa tumulosa.**
    - *Leiaster analogus.**
    - *Anseropoda macropora.**
    - *Acanthaster brevispinus.**
2. From 100 to 200 fathoms:
    - *Astroceramus sphaeriostictus.**
3. From 200 to 300 fathoms:
    - *Prionaster analogus.*
4. From 300 to 500 fathoms:
    - *Benthogenia cribellosa.*
    - *Astropecten pedicellaris.**
    - *Nymphaster habrotatus.*
5. From 500 to 700 fathoms:
    - *Persephonaster suluensis.**
    - *Sphaeriodiscus scotocryptus.**
    - *Lophaster suluensis.**
    - *Nymphaster habrotatus* (to 736 fathoms).
6. From 900 to 1,100 fathoms:
    - *Nymphaster atopus.**
    - *Hymenaster bartschi* (1105).

(*f*) Species found in the Sulu and Mindanao Seas which were taken also outside these basins, as follows:

a′. In the China Sea off Luzon, or in tributary bays:

- *Astropecten phragmorus* (14 to 44 fathoms).
- *Persephonaster euryactis brevispinus* (172–258 fathoms).
- *Persephonaster habrogenys* (305–340 fathoms; Sibuko Bay, Borneo).
- *Perissogonaster insignis* (159–254 fathoms).
- *Anthenoides cristatus* (102–279 fathoms).
- *Zoroaster carinatus philippinensis* (96–604 fathoms).

b′. In interisland waters, central part of archipelago:

1. In less than 100 fathoms:

    Astropecten phragmorus, *Astropecten mindanensis* (4 to 42 feet), *Luidia longispina*, *Luidia prionota*, *Zoroaster c. philippinensis.*

2. From 100 to 200 fathoms:

   Astropecten eucnemis, *A. tenellus*, *Ctenopleura astropectinides*, *Anthenoides cristatus*, *Zoroaster c. philippinensis.*

3. From 200 to 300 fathoms:

   Lithosoma penichra, *Anthenoides cristatus*, *Anthenoides rugulosus*, *Zoroaster c. philippinensis.*

4. From 300 to 500 fathoms:

   Prionaster gracilis, *Dipsacaster diaphorus*, *Lithosoma penichra*, *Anthenoides rugulosus*, *Zoroaster c. philippinensis.*

5. From 500 to 700 fathoms:

   Astropecten eremicus, *Dipsacaster diaphorus*, *Zoroaster c. philippinensis*, *Brisinga trachydisca.*

6. From 700 to 800 fathoms: *Brisinga trachydisca.*

(*g*) Species taken only in Palawan Passage or tributary bays:
Pectinaster mimicus palawanensis (730 fathoms).
Asterina coronata euerces (littoral).
Craterobrisinga eucoryne (375 fathoms).
Craterobrisinga analoga (375 fathoms).

(*h*) Bathymetric distribution of deep-water species. Those marked with an * occur also outside the archipelago as detailed under section I. This list includes I, *l*.

1. From 100 to 200 fathoms:

Goniopecten asiaticus.
Astropecten eucnemis.
*Astropecten granulatus.**
Astropecten luzonicus.
Astropecten tenellus.
Ctenopleura astropectinides.
Ctenophoraster diploctenius.
*Persephonaster anchistus.**
Persephonaster euryactis.
Persephonaster e. brevispinus.
Astromesites compactus.
Anthosticte aulophora.
*Luidia aspera.**
Luidia avicularia.
Paragonaster ctenipes hypacantha.
Paragonaster stenostichus.
Perissogonaster insignis.
*Rosaster symbolicus.**
Nymphaster euryplax.
Peltaster cycloplax.
Pontioceramus grandis.
Lithosoma actinometra.
Astroceramus sphaeriostictus.
Calliaster corynetes.
Astrothauma euphylacteum.

Anthenoides cristatus.
Tarachaster tenuis.
*Henricia densispina.**
Henricia microplax.
Zoroaster c. philippinensis.
Pholidaster squamatus.
Coronaster volsellatus.
*Coronaster halicepus.**
*Distolasterias euplecta.**
Distolasterias hypacantha.
Astrostephane acanthogenys.
Odinia penichra.

2. From 200 to 300 fathoms:

Prionaster analogus.
Astropecten luzonicus.
Persephonaster e. brevispinus.
Persephonaster luzonicus.
Persephonaster oediplax.
Tritonaster evorus.
Luidia gymnochora.
*Cheiraster inops.**
*Cheiraster niasicus.**
Perissogonaster insignis.
Rosaster mimicus.
Nymphaster dyscritus.
Nymphaster mucronatus.
Nymphaster leptodomus.
Lithosoma penichra.
Anthenoides cristatus.
Anthenoides rugulosus.
*Henricia densispina.**
Henricia arcystata.
Pteraster obesus myonotus.
*Hymenasterides zenognathus.**
Zoroaster c. philippinensis.
*Coronaster halicepus.**
Brisingella fragilis.

3. From 300 to 500 fathoms:

Benthogenia cribellosa.
*Ctenodiscus orientalis.**
Prionaster gracilis.
Astropecten pedicellaris.
Psilaster gotoi.
Persephonaster oediplax.
Persephonaster habrogenys.
Dipsacaster imperialis.
Dipsacaster diaphorus.
*Pectinaster hylacanthus.**
Cheiraster inops.
Cheiraster diomedeae.
*Pseudarchaster jordani.**
Nymphaster meseres.
Nymphaster habrotatus.
Lithosoma penichra.
Anthenoides rugulosus.
Henricia densispina.
Zoroaster c. philippinensis.
*Brisingella fragilis.**
Craterobrisinga eucoryne.
Craterobrisinga analoga.

4. From 500 to 700 fathoms:

Astropecten eremicus.
Persephonaster suluensis.
*Persephonaster oediplax.**
Dipsacaster diaphorus.
*Cheiraster inops.**
Nymphaster habrotatus (to 736 fathoms).
Ceramaster smithi.
Sphaeriodiscus scotocryptus.
*Atelorias anacanthus.**
Henricia arcystata (to 530 fathoms).
Lophaster suluensis.
*Zoroaster ophiactis.**
Zoroaster c. philippinensis.
Brisinga trachydisca.
*Brisinga placoderma.**
*Stegnobrisinga placoderma.**

5. From 700 to 1,100 fathoms:

Koremaster evaulus spiculatus.
Pectinaster mimicus palawanensis.
Pseudarchaster jordani.
Nymphaster atopus.
Hymenaster bartschi (1,105 fathoms).
*Zoroaster ophiactis.**
*Cnemidaster wyvillii.**
Brisinga trachydisca.

The following table indicates the distribution of all forms collected in the Philippine Islands only:

DISTRIBUTION OF SPECIES COLLECTED AMONG THE PHILIPPINES ONLY.

	Luzon.	Central Philippines.	Palawan Passage.	Sulu Sea.	Mindanao and Surigao Sea.	Sulu Archipel.	Range in fathoms.						
							0-100.	100-200.	200-300.	300-500.	500-700.	700-900.	900-1,100.
Benthogenia cribellosa				×	×					×			
Goniopecten asiaticus		×						×					
Prionaster analogus				×	×				×				
Prionaster gracilis		×		×						×			
Astropecten phragmorus	×	×	×	×		×	×						
Astropecten mindanensis		×		×	×								
Astropecten vappa inaequalis						×							
Astropecten eucnemis		×				×		×					
Astropecten eremicus		×			×						×		
Astropecten luzonicus	×							×	×				
Astropecten tenellus	×	×			×			×					
Astropecten pedicellaris				×						×			
Ctenopleura astropectinides		×			×			×					
Ctenophoraster diploctenius	×							×					
Psilaster gotoi	×									×			
Astromesites compactus	×							×					
Persephonaster euryactis	×							×					
Persephonaster e. brevispinus	×			×				×	×				
Persephonaster luzonicus	×								×				
Persephonaster suluensis				×						×			
Persephonaster oediplax		×							×	×	×		
Persephonaster habrogenys	×			×[a]						×			

[a] Sibuko Bay, Borneo.

DISTRIBUTION OF SPECIES COLLECTED AMONG THE PHILIPPINES ONLY—Continued.

	Luzon.	Central Philippines.	Palawan Passage.	Sulu Sea.	Mindanao and Surigao Sea.	Sulu Archipel.	Range in fathoms.						
							0-100.	100-200.	200-300.	300-500.	500-700.	700-900.	900-1,100.
Tritonaster evorus	×								×				
Anthosticte aulophora		×						×					
Dipsacaster imperialis	×									×			
Dipsacaster diaphorus		×		×	×					×	×	×	
Patagiaster sphaerioplax		×					×						
Koremaster e. spiculatus		×										×	
Luidia longispina		×				×	×						
Luidia prionota		×				×	×						
Luidia avicularia		×						×					
Luidia gymnochora		×						×	×				
Pectinaster m. palawanensis			×									×	
Cheiraster diomedeae					×					×			
Paragonaster c. hypacanthus	×	×						×					
Paragonaster stenostichus	×							×					
Perissogonaster insignis	×				×			×	×				
Rosaster nannus				×		×	×						
Rosaster mamillatus		×					×						
Rosaster mimicus	×								×				
Ceramaster smithi		×									×		
Nymphaster euryplax					×			×					
Nymphaster dyscritus					×				×				
Nymphaster mucronatus	×								×				
Nymphaster leptodomus		×							×				
Nymphaster meseres	×									×			
Nymphaster habrotatus				×	×					×	×	×	
Nymphaster atopus				×									×
Sphaeriodiscus scotocryptus				×						×			
Peltaster cycloplax	×							×					
Pontioceramus grandis	×	×						×					
Lithosoma actinometra	×							×					
Lithosoma penichra		×		×					×	×			
Iconaster perierctus						×	×						
Astroceramus lionotus					×								
Astroceramus sphaeriostictus						×		×					
Calliaster corynetes	×							×					
Astrothauma euphylacteum		×						×					
Anthenoides cristatus	×	×			×			×	×				
Anthenoides rugulosus		×			×				×	×			
Pentaceropsis tyloderma					×		×						
Asterodiscus helonotus						×	×						
Halityle regularis						×	×						
Fromia eusticha						×	×						
Fromia hemiopla				×		×	×						
Nardoa tumulosa						×	×						
Ophidiaster trychnus		×					×						
Leiaster analogus						×	×						
Bunaster lithodes		×					×						
Tarachaster tenuis					×			×					
Asterinopsis pedicellaris		×					×						
Asterina coronata euerces			×				×						
Anseropoda macropora						×	×						
Echinaster stereosomus					×		×						
Henricia microplax					×			×					
Henricia arcystata		×							×	×	×		
Acanthaster brevispinus						×	×						
Lophaster suluensis				×							×		
Pteraster obesus myonotus					×		×		×				
Hymenaster bartschi				×									×
Zoroaster c. philippinensis	×	×		×	×	×	×	×	×	×	×		
Pholidaster squamatus		×						×					
Distolasterias hypacantha		×					×	×					
Coronaster volsellatus	×	×					×	×					
Odinia penichra		×						×					
Odinia magister		×											
Brisinga trachydisca		×			×						×	×	
Astrostephane acanthogenys	×							×					
Craterobrisinga eucoryne			×							×		×?	
Craterobrisinga analoga			×							×			

III. Relationships of Philippine Fauna.

As summarized at the end of Section I, the species which range beyond Philippine waters include: First, about 25 species with a wide Indo-Pacific distribution and a very slight vertical range below low tide (Section I, *a*, *b*, *c*); second, 19 species which extend to Celebes or to the Molucca Islands and the seas at the south (Section I, *i*, *j*); third, 6 species which occur in the Bay of Bengal and 1 in the Arabian Sea (Section I, *d*, *e*); fourth, 5 species which range to the Hawaiian Islands (*k*), of which 3 also extend to the Indian region (all deep water); fifth, 3 species which are members of the Japanese fauna, 1 being also Pacific (*h*). Of the remaining 6, 3 are China Sea species and 3 are from the western Pacific.

Excluding the widely distributed Indo-Pacific forms, the remainder seem to show a preference for the seas to the south of the Philippines and for the Bay of Bengal.

If the deep-water species alone are considered the following is the result: 10 species range to Celebes and the Moluccas, and 3 others to the Arafura Sea; 3 species extend from Hawaii to the Indian region; 2 from the Philippines to Hawaii; 1 to the Straits of Korea (not free from doubt as to specific identity).

If the species which were taken only in the Philippine Islands are listed along with their nearest known relatives, somewhat similar results are obtained. In the three tables which follow, certain species (marked with an asterisk) are included which range into the China Sea or to the Celebes region. Of course it is likely that nearly all the species considered have a much more extended distribution than the limited data warrant us in asserting.

It will be seen that 25 species have relatives in the Indian region, although in some cases showing kinship with Pacific or Moluccan forms; 12 have related forms in the region from Celebes to Torres Strait; 12 have related species ranging to, or so far as known, confined to the Hawaiian Islands; 7 have Japanese affiliations (shared in some cases with Indian connections); and 5 others have representative forms in distant parts of the Pacific. One form, not listed below, *Astropecten vappa inaequalis*, is closely related to *A. vappa* of New South Wales and southwest Australia.

PHILIPPINE SPECIES WITH APPARENT NEAREST RELATIVES IN THE INDIAN REGION.

Philippine species.	Related species.	Habitat of related species.
Astropecten mindanensis	*A. andersoni*	Bay of Bengal.
Astropecten tenellus	*A. griegi* Koehler	Bay of Bengal, Indian Ocean.
Astropecten pedicellaris	do	Do.
	A. tenellus Fisher [1]	Philippines, shallower water.
Psilaster gotoi	*P. agassizi* (Koehler) not very close	Bay of Bengal.
	P. robustus Fisher	Moluccas.

[1] In a number of cases 2 related species are given.

PHILIPPINE SPECIES WITH APPARENT NEAREST RELATIVES IN THE INDIAN REGION—Continued.

Philippine species.	Related species.	Habitat of related species.
Persephonaster euryactis	*P. coelochiles* Alcock	Andaman Sea.
	P. misakiensis Goto	Japan.
Dipsacaster imperialis	*D. sladeni* Alcock	Andaman Sea.
	D. nesiotes Fisher	Hawaiian Islands.
Luidia avicularia	*L. integra* Koehler	Andaman Islands.
	L. moroisoana Goto (not so close)	Japan.
Luidia gymnochora	*L. denudata* Koehler	Coromandel Coast, India.
**Cheiraster niasicus*	*C. inops* Fisher	Hawaiian Islands, Bay of Bengal.
	C. pilosus (Alcock)	Gulf of Manaar.
Rosaster nannus	*R. confinis* (Koehler)	Andaman Islands.
Nymphaster euryplax	*N. belli* (Koehler)	Do.
Nymphaster dyscritus	*N. ternalis* (Koehler, not Perrier)	Bay of Bengal, Indian Ocean
	N. gardineri (Bell)	Western Indian Ocean.
Nymphaster mucronatus	*N. belli* (Koehler)	Andaman Islands.
Lithosoma actinometra	*L. pentaphylla* (Alcock)	Andaman Sea.
Anthenoides cristatus	*A. sarissa* (Alcock)	Do.
Fromia hemiopla	*F. armata* Koehler	Andaman Islands.
Nardoa tumulosa	*N. frianti* Koehler	Andaman Islands, Philippine Islands.
Leiaster analogus	*L. coriaceus* Peters	Mauritius.
Henricia arcystata	*H. mutans* (Koehler)	Andaman Islands.
Acanthaster brevispinus	*A. mauritiensis* de Loriol?	Mauritius.
**Zoroaster ophiactis*	*Z. alfredi* Alcock	Bay of Bengal.
Zoroaster c. philippinensis	*Z. carinatus* Alcock	Andaman Sea.
**Cnemidaster wyvillii*	*C. zea* (Alcock)	Laccadive Sea.
	C. squameus (Alcock)	Laccadive Sea; Gulf of Manaar.
Distolasterias hypacantha	*D. mazophorus* (Alcock)?	Andaman Sea.
Brisinga trachydisca	*B. andamanica* Alcock	Do.

* Species so marked range outside the Philippines.

PHILIPPINE SPECIES WHOSE NEAREST RELATIVES HAVE BEEN TAKEN IN THE REGION OF THE CELEBES AND MOLUCCAS, OR BANDA AND ARAFURA SEAS.

Philippine species.	Related species.	Habitat of related species.
Astropecten phragmorus	*A. acanthifer* Sladen	Banda Sea.
Astropecten eucnemis	*A. granulatus* Müller and Troschel	Banda and Arafura Seas; Philippines.
Psilaster gotoi	*P. robustus* Fisher	Moluccas.
Persephonaster suluensis	*P. multicinctus* Fisher	Celebes.
Koremaster e. spiculatus	*K. evaulus* Fisher	Do.
Luidia prionota	*L. forficifera* Sladen	Arafura Sea; Torres Strait.
Pectinaster m. palawanensis	*P. mimicus* (Sladen)	Celebes; Arafura Sea.
Pholidaster squamatus	*P. distinctus* Sladen	Banda Sea.
Paragonaster c. hypacanthus	*P. ctenipes* Sladen	Arafura Sea.
Nymphaster mesceres	*N. arthrocnemis* Fisher	Celebes.
Pentaceropsis tyloderma	*P. obtusata* (B. de St. Vincent)	Amboina; Philippines.
Bunaster lithodes	*B. ritteri* Döderlein	Amboina.

PHILIPPINE SPECIES WHOSE APPARENT NEAREST RELATIVES LIVE IN THE PACIFIC.

Philippine species.	Related species.	Habitat of related species.
**Ctenodiscus orientalis*	*C. crispatus* (Retzius)	N., E., and S. Pacific; N. Atlantic.
Astropecten eremicus	*A. pusillulus* Fisher	Hawaiian Islands.
Ctenopleura astropectinides	*C. ludwigi* (de Loriol)	Japan.
Ctenophoraster diploctenius	*C. hawaiiensis* Fisher	Hawaiian Islands.
Persephonaster euryactis	*P. misakienses* Goto	Japan.
**Persephonaster anchistus*	do.	Do.
Tritonaster acerus	*T. craspedotus* Fisher	Hawaiian Islands.
Dipsacaster imperialis	*D. nesiotes* Fisher	Hawaiian Islands; Moluccas.
	D. sladeni Alcock	Andaman Sea.
Patagiaster sphaerioplax	*P. nuttingi* Fisher	Hawaiian Islands.
**Luidia orientalis*	*L. asthenosoma*	California.
Luidia avicularia	*L. moroisoana* Goto	Japan.
	L. integra Koehler	Andaman Islands.

* Species so marked have a known range outside the Philippines.

PHILIPPINE SPECIES WHOSE APPARENT NEAREST RELATIVES LIVE IN THE PACIFIC—Continued.

Philippine species.	Related species.	Habitat of related species.
**Cheiraster niasicus*	*C. inops* Fisher	Hawaiian Islands; Bay of Bengal.
Cheiraster gazellae	*C. snyderi* Fisher	Hawaiian Islands.
Cheiraster diomedeae	do	Do.
Ceramaster smithi	*C. clarki* Fisher (not close)	W. coast of North America.
Astroceramus lionotus	*A. callimorphus* Fisher	Hawaiian Islands.
Astroceramus sphaeriostictus	*A. callimorphus* (not close)	Do.
Calliaster corynetes	*C. pedicellaris* Fisher	Do.
Asterodiscus helonotus	*A truncatus* Coleman	S. and S. E. Australia.
Asterina coronata euerces	*A. coronata cristata* Fisher	Caroline Islands; N. Australia
Anseropoda macropora	*A. petaloides* Goto	Japan.
Lophaster suluensis	*L. furcilliger* Fisher	W. coast of North America.
Pteraster obesus myonotus	*P. obesus* Clark	Japan.
Hymenaster bartschi	*N. pullatus* Sladen	N. coast of New Guinea.
Craterobrisinga eucoryne	*C. alberti* Fisher	Hawaiian Islands.

* Species so marked have a known range outside the Philippines.

IV. ANALYSIS OF SPECIES TAKEN OUTSIDE OF PHILIPPINE WATERS.

(*a*) Species confined so far as known to the China Sea but not occurring in Philippine waters:

Persephonaster tenuis.
Luidia orientalis.
Anthenoides lithosorus.
Marginaster paucispinus.

(*b*) Species taken only in the Celebes and Moluccan region:

Radiaster notabilis.
Solaster tropicus.
Astrostephane moluccana.

(*c*) Species taken from Celebes waters only:

1. Strait of Macassar—
   Benthopecten styracius.
   Tarsaster distichopus.
   Freyellaster spatulifer.
2. Gulf of Tomini—
   Persephonaster monostoechus.
   Koremaster evaulus.
   Pseudarchaster oligoporus.
   Myxaster medusa.
   Hymenaster rhodopeplus.
3. Buton Strait—
   Persephonaster multicinctus.
   Aphroditaster microceramus.
   Nymphaster arthrocnemis.
   Ferdina glyptodisca.
   Paranepanthia platydisca.
   Bythiolophus acanthinus.
   Brisingenes mimica.
   Brisingenes anchista.

4. Gulf of Boni—

Cheiraster triplacanthus.
Benthopecten polyctenius.
Nymphaster arthrocnemis.
Crossaster scotophilus.
Diplopteraster multipes patagiatus.
Pedicellaster chirophorus.

5. Flores Sea: *Cheiraster ludwigi.*

(*d*) Species taken only among the Molucca Islands:

Prionaster megaloplax.
Psilaster robustus.
Benthopecten moluccanus.
Nymphaster moluccanus.
Anthenoides granulosus.
Dissogenes styracia.
Xenorias polyctenius.
Pteraster corynetes.
Zoroaster microporus.

(*e*) Species common to the Molucca and Hawaiian Islands: *Dipsacaster nesiotes.*

(*f*) Species common to the Moluccas and Philippines, lists *i* and *j* under II.

(*g*) Bathymetric Distribution (see also *l* under II):

1. From less than 100 fathoms: *Ferdina glyptodisca.*
2. From between 100 and 200 fathoms:

Persephonaster tenuis.
Dissogenes styracia.
Marginaster paucispinus.

3. From between 200 and 300 fathoms:

Prionaster megaloplax.
Dipsacaster nesiotes.
Luidia orientalis.
Nymphaster moluccanus.
Anthenoides lithosorus.
Anthenoides granulosus.
Paranepanthia platydisca.
Xenorias polyctenius.
Pteraster corynetes.
Astrostephane moluccana.

4. From between 300 and 500 fathoms:

Benthopecten moluccanus.
Solaster tropicus.
Diplopteraster multipes patagiatus.
Tarsaster distichopus.
Pedicellaster chirophorus.

5. From between 500 and 700 fathoms:

Psilaster robustus.
Persephonaster multicinctus.
Cheiraster triplacanthus (700).
Cheiraster ludwigi.
Radiaster notabilis.
Aphroditaster microceramus.

Nymphaster arthrocnemis.
Crossaster scotophilus (700).
Myxaster medusa.
Zoroaster microporus.
Bythiolophus acanthinus.
Brisingenes mimica.
Brisingenes anchista.

6. From between 701 and 901 fathoms:

Persephonaster monostoechus.
Koremaster evaulus.
Benthopecten polyctenius.
Benthopecten styracius (901).
Hymenaster rhodopeplus.
Freyellaster spatulifer (901).

7. From between 901 and 1.200 fathoms: *Pseudarchaster oligoporus* (1092).

V. Relationships of Celebes-Moluccan Species.

As already pointed out in Section I there are 19 species common to the Philippines, Celebes, and Moluccas, or the seas to the south. The Moluccan area is included in the range of most of the 25 Indo-Pacific species listed in Section I, *a*, *b*, and *c*.

In the table below are listed 24 Celebes and Moluccan species (not collected outside this region) and their nearest known relatives. Nine have relatives in the Bay of Bengal, Laccadive Sea, or Indian Ocean adjacent to these areas; 3 have Philippine affiliations; 3 show a tendency toward Japanese forms, and 2 have Hawaiian relations (in addition to one, *Dipsacaster nesiotes*, common to the two regions). The remainder are scattered as far as the Azores, Marion Island, and the north Atlantic.

Some Celebes and Moluccan species with apparent nearest Relatives.

Celebes-Moluccan species.	Related species.	Habitat of related species.
Prionaster megaloplax	*P. analogus* Fisher	Philippine Islands.
Psilaster robustus	*P. gotoi* Fisher	Do.
Persephonaster multicinctus	*P. roulei* Koehler	Indian Ocean.
	P. cingulatus (Fisher)	Hawaiian Islands.
Persephonaster monostoechus	*P. croceus* Alcock and Wood-Mason	Gulf of Manaar.
Cheiraster ludwigi	*C. trullipes* (Sladen) not close	West of Luzon.
Cheiraster triplacanthus	*C. subtuberculatus* (Sladen)	Off eastern Australia.
Benthopecten moluccanus	*B. huddlestonii* (Alcock)	Bay of Bengal.
Benthopecten polyctenius	*B. violaceus* (Alcock)	Laccadive Sea.
Benthopecten styracius	*B. violaceus* (Alcock)	Do.
	B. polyctenius	Celebes.
Radiaster notabilis	*R. tizardi* (Sladen)	North Atlantic.
	R. elegans Perrier	West Indies.
Pseudarchaster oligoporus	*P. pectinifer* Ludwig (not close)	Eastern Pacific.
	P. dissonus Fisher (not close)	North Pacific.
Aphroditaster microceramus	*A. gracilis* Sladen	Azores.
Nymphaster moluccanus	*N. ludwigi* (Koehler)	Vicinity Laccadive Islands.
Anthenoides granulosus	*A. epixanthus* (Fisher)	Hawaiian Islands.
Ferdina glyptodisca	*F. offreti* Koehler	Ceylon and Andaman Islands.
Paranepanthia platydisca	*P. brachiata* (Koehler)	Andaman Islands.
Solaster tropicus	*S. paxillatus* Sladen	Japan; North Pacific.
Crossaster scotophilus	*C. japonicus* (Fisher)	Japan.
	C. penicillatus Sladen	Marion Island.
Myxaster medusa	*M. sol* Perrier	Atlantic.
Pteraster coryncetes	*P. semireticulatus* Sladen	Marion Island.
Diplopteraster m. patagiatus	*D. multipes* (Sars)	North Pacific; north Atlantic.
Hymenaster rhodopeplus	*H. nobilis* Sladen	South of Australia.
	H. koehleri Fisher	North Pacific.
Zoroaster microporus	*Z. barathri* Alcock	Bay of Bengal.
Tarsaster distichopus	*T. stoichodes* Sladen	North of Admiralty Islands.

Previous to the *Albatross* expedition *Goniopecten* and *Prionaster*, two well-marked genera composing the Goniopectininae, were known only by a single species each from the West Indies. A very different, nearly subgenerically distinct species of *Goniopecten* was collected in the Philippines, and 3 new forms of *Prionaster* were added, one of which is close to the type, while the others are entirely different. The capture of a very distinct *Ctenodiscus* in the Philippine and Moluccan region greatly extends the range of this genus.

A new species of the Indian genus *Sidonaster* was added, and the range of *Sidonaster vaneyi* greatly extended.

The number of new, delicate deep-water Astropectens and of new Persephonasters, Luidias, Benthopectens, Rosasters, and Nymphasters is perhaps noteworthy.

The following genera previously known only from distant Atlantic stations have provided each a new species: *Radiaster* (olim *Mimaster*), *Aphroditaster*, *Peltaster*, *Marginaster*, and *Myxaster*.

The well-known *Diplopteraster multipes* is represented in Celebes waters by a small species or subspecies apparently most nearly related to the Japanese variant of true *multipes*.

Additions to genera first made known by the *Albatross* in Hawaiian waters in 1902 are as follows:

Ctenophoraster (second species).
Tritonaster (second species).
Patagiaster (second species).
Astroceramus (third and fourth species).

Among the new generic types the following are rather isolated: *Benthogenia*, *Atelorias*, *Dissogenes*, *Tarachaster*, *Bythiolophus*.

The following are also monotypic, but their nearest relatives are fairly obvious and are indicated in parentheses:

Astromesites (*Persephonaster*).
Anthosticte (*Tethyaster*, *Moiraster*).
Perissogonaster (*Paragonaster*).
Pontioceramus (*Eugoniaster and Plinthaster*).
Astrothauma (*Calliaster*).
Halityle (*Culcita* and *Oreaster*; a second species subsequently described).
Xenorias (*Rhipidaster*).
Hymenasterides (*Hymenaster*).

Additional new genera:

Ctenopleura (*Astropecten*).
Koremaster (*Dytaster*).
Lithosoma (*Iconaster*).
Paranepanthia (*Nepanthia*).
Freyellaster (*Freyella*).
Brisingenes (*Brisinga*).

Brisingella (*Brisinga*).
Astrostephane (*Brisinga*).
Craterobrisinga (*Brisinga*).
Stegnobrisinga (*Brisinga*).

Taking the collection as a whole it is characterized by the numerous species belonging to the Phanerozonia (139) and the few which fall in the Spinulosa and the Forcipulata, these being mainly deep-water forms. There are but 3 species of Asteriidae, a family very poorly represented at any depth in the Tropics, while extraordinarily numerous in the north Pacific, particularly on the American coast. The census of species by families is as follows:

Porcellanasteridae, 4.
Goniopectinidae, 5.
Astropectinidae, 36.
Luidiidae, 8.
Archasteridae, 2.
Benthopectinidae, 12.
Radiasteridae, 1.
Goniasteridae, 39.
Oreasteridae, 9.
Linckiidae, 21.
Metrodiridae, 1.
Ganeriidae, 1.
Poraniidae, 1.
Asterinidae, 9.
Echinasteridae, 6.
Acanthasteridae, 2.
Solasteride, 4.
Myxasteridae, 1.
Pterasteridae, 7.
Zoroasteridae, 6.
Asteriidae, 3.
Pedicellasteridae, 3.
Brisingidae, 12.

The following species attributed to the Philippine Islands were not secured by the *Albatross* expedition:

Astropecten imbellis Sladen; Sladen, 1889.
Dystaster inermis Sladen, Celebes Sea; Sladen, 1889.
Cheiraster trullipes (Sladen); Sladen, 1889.
Anthenea spinulosa (Gray); Gray, 1840.
Oreaster productus tuberatus (Sladen); Sladen, 1889.
Pentaceropsis obtusata (Bory de Saint Vincent); Sladen, 1889.
Ophidiaster pusillus (Müller and Troschel); Müller and Troschel, 1842.
Nardoa obtusa (Perrier); Perrier, 1875.
Freyella echinata Sladen; Sladen, 1889.

LIST OF STARFISHES RECORDED FROM CELEBES AND THE MOLUCCAS, INCLUDING BOURO, AMBOINA, AND CERAM.

Species marked with an asterisk were taken by the *Albatross* in this region.

Acanthaster planci (Linnaeus). Bay of Amboina (de Loriol, '93:387; Döderlein, '96:320); Moluccas (Sluiter, '95:63).[1]

Anthenea flavescens (Gray). Moluccas (Sluiter, '95:305).

---

[1] These abbreviated citations refer to Bibliographic index; the first figure indicates the year, the second the page.

**Anthenoides granulosus* Fisher. Between Gillolo and Kayoa, Moluccas.

**Aphroditaster microceramus* Fisher. Buton Strait, Celebes.

Archaster typicus Müller and Troschel. Bay of Amboina (de Loriol, '93:378; Döderlein, '96:305); Batjan, Moluccas (von Martens, '66:84); Moluccas (Sluiter, '95:52).

Asterias tenuispina Lamarck. Moluccas (Müller, Wieg. Archiv., '43).[1]

Asterina cepheus (Müller and Troschel). Bay of Amboina (de Loriol, '93:383; '96:316); Moluccas, Amboina (Sluiter, '95:59).

Asterina coronata von Martens. Batjan, Moluccas; Amboina (von Martens, '66:73).

Asterina exigua (see *Patiriella exigua*).

Asterina penicillaris (see *Asterinopsis penicillaris*).

Asterinopsis penicillaris (Lamarck). Moluccas. (von Martens, '66:74).

Asterope carinifera (Gray). Amboina (von Martens, 66:74; Döderlein, '96:316); Moluccas (Sluiter, '95:59).

Astropecten acanthifer Sladen. Banda Sea (Sladen, 1889).

Astropecten alatus Perrier. Amboina [Ambon] (Sluiter, '95:53; Döderlein, 1917:174).

Astropecten andersoni Sladen. Moluccas (Döderlein, 1917:177).

Astropecten bandanus Döderlein. Banda Sea, 204 meters (Döderlein, 1917:50, 118, 175).

Astropecten celebensis Döderlein. South Celebes, 462 meters (Döderlein, 1917:50,118,175).

Astropecten polyacanthus Müller and Troschel. Amboina (de Loriol, '93); Moluccas (Sluiter, '95:53).

Astropecten ternatensus Sluiter. Moluccas (Sluiter, '95:53).[2]

Astropecten velitaris von Martens. Amboina (von Martens, '65:360); Döderlein, '96:307). Macassar, 27–32 meters (Döderlein, 1917:159).

Astropecten zebra sibogae Döderlein. Macassar, 27–32 meters (Döderlein, 1917:54, 156, 182).

**Astrostephane moluccana* Fisher. Buton Strait, Celebes; vicinity of Kayoa and Gillolo, Moluccas.

**Atelorias anacanthus* Fisher. Gulf of Boni, Celebes.

**Benthopecten moluccanus* Fisher. Molucca Passage.

**Benthopecten polyctenius* Fisher. Gulf of Boni, Celebes.

**Benthopecten styracius* Fisher. Strait of Macassar.

**Brisingenes anchista* Fisher. Buton Strait, Celebes.

**Brisingenes mimica* Fisher. Buton Strait, Celebes.

Bunaster ritteri Döderlein. Amboina (Döderlein, 96:318).

---

[1] Possibly *Coscinasterias calamaria*.

[2] See Döderlein, 1917, p. 72. Döderlein considers this species to be *A. irregularis serrata* Müller and Troschel "mit unrichtigem fundort."

* *Bythiolophus acanthinus* Fisher. Buton Strait, Celebes.

* *Cheiraster niasicus* Ludwig. Gulf of Boni, Celebes; Molucca Passage; vicinity of Gillolo, Makyan and Kayoa, Moluccas.

* *Cheiraster triplacanthus* Fisher. Gulf of Boni, Celebes.

* *Choriaster granulatus* Lütken. Togian Bay, Togian Island, Gulf of Tomini, Celebes.

* *Cnemidaster wyvillii* (Sladen). Gulf of Tomini, Celebes.

* *Coronaster halicepus* Fisher. Off Molucca Passage.

* *Crossaster scotophilus* (Fisher). Gulf of Boni, Celebes.

* *Ctenodiscus orientalis* Fisher. Molucca Passage; Gulf of Boni and Gulf of Tomini, Celebes.

Culcita arenosa[1] Perrier. Amboina; Ceram Laut (Hartlaub, '92); Amboina (Döderlein, '96:315).

Culcita grex Müller and Troschel. Moluccas (Hartlaub, '92); Bay of Amboina (de Loriol, '93:382).

Culcita novae-guineae Müller and Troschel. Amboina (Hartlaub, '92; Döderlein, '96:310); Moluccas (Sluiter, '95:51).

Culcita plana[1] Hartlaub. Amboina (Hartlaub, '92).

Culcita schmideliana (Retzius). Amboina (von Martens, '66:71, as *C. discoidea*).

* *Diplopteraster multipes patagiatus* Fisher. Gulf of Boni, Celebes.

* *Dipsacaster nesiotes* Fisher. Between Gillolo and Makyan, Moluccas.

* *Dissogenes styracia* Fisher. Off Ternate.

Dytaster inermis Sladen. North of Celebes (Sladen, '89).

* *Echinaster callosus* von Marenzeller. Binang Unang Island, Gulf of Tomini, Celebes.

Echinaster eridanella Müller and Troschel. (See *Othilia eridanella*).

Echinaster purpureus Gray. (See *Othilia purpurea.*)

* *Ferdina glyptodisca* Fisher. Buton Strait, Celebes.

* *Freyellaster spatulifer* Fisher. Strait of Macassar.

Fromia milleporella (Lamarck). Amboina (von Martens '66:70); Moluccas (Sluiter '95:60).

Fromia monilis Perrier. Amboina (Studer, '84:30).

[*Goniaster cuspidatus* (Gray). Celebes (von Martens, '66:86, as *semilunatus*)].

Goniodiscaster pleyadella (Lamarck). Moluccas (von Martens, '66:86).

Gymnasteria carinifera. (See *Asterope carinifera*).

* *Hymenaster rhodopeplus* Fisher. Gulf of Tomini, Celebes.

* *Hymenasterides zenognathus* Fisher. Molucca Passage, near Makyan Island.

---

[1] Regarded as a race or variety of *novaeguineae.*

Koremaster evaulus Fisher. Gulf of Tomini, Celebes.

Leiaster leachii (Gray). Moluccas (Sluiter, '95:60).

Linckia laevigata (Linnaeus). Strait of Macassar, Celebes; Batjan, Moluccas; Amboina (von Martens, '66:65); Bay of Amboina (de Loriol, '93:385; Döderlein, '96:319).

Linckia guildingii Gray. Amboina (Sluiter, '95:60, as *pacifica*).

* *Linckia multifora* (Lamarck). Strait of Macassar, Celebes; Amboina (von Martens, '66:66; Sluiter, '95:60; and Döderlein, '96:319, Amboina); Tomahu Island, near Bouro Island (*Albatross*).

Linckia rosenbergi von Martens. Amboina (von Martens, '66:64).

Luidia maculata Müller and Troschel. Bay of Amboina (de Loriol, '93:379).

Metrodira subulata Gray. Amboina (von Martens, '67:109; Studer, '84:31).

Mithrodia clavigera (Lamarck). Moluccas (von Martens, '66:59, as *Echinaster echinulatus;* Sluiter, '95:83): Amboina (Döderlein, '96:322).

* *Myxaster medusa* (Fisher). Gulf of Tomini, Celebes.

Nardoa galatheae (Lütken). Togean Island, Gulf of Tomini, Celebes (Sladen, '89).

Nardoa novae-caledoniae (Perrier). Moluccas (Sluiter, '95:60).

Nardoa pauciforis (von Martens). Amboina (Sluiter, '95:61).

Nardoa semiregularis (Müller and Troschel). Moluccas (Sluiter, '95:61).

* *Nardoa tuberculata* Gray. Amboina (von Martens, '66:61, as *Linckia tuberculata;* de Loriol, '93:386; Döderlein, '96:319); Moluccas (von Martens, '66:61; Sluiter, '95:61); Great Tobea Island, Buton Strait, Celebes (*Albatross*).

Nectria ocellifera (Lamarck). Amboina (Ambon) (Sluiter, '95:55).

Nymphaster moluccanus Fisher. Vicinity of Makyan, Gillolo, and Kayoa, Moluccas.

* *Nymphaster arthrocnemis* Fisher. Buton Strait, Celebes.

Ophidiaster cylindricus (Lamarck). Amboina (Sluiter, '95:60; Moluccas (Sladen, '89).

* *Ophidiaster fuscus* (Gray). Kalono Point, Buton Strait, Celebes.

Ophidiaster purpureus Perrier. Bay of Amboina (de Loriol, '93:385; Moluccas (Sluiter, '95:60).

Ophidiaster pusillus Müller and Troschel. Moluccas (Sluiter, '95:60).

Ophidiaster pustulatus (von Martens). Amboina (von Martens, '66:63; Döderlein, '96:317).

Oreaster affinis (Müller and Troschel). Moluccas (Sluiter, '95:55).

Oreaster grayi Bell. Moluccas, Amboina (Sluiter, '95:55).

Oreaster hiulcus (Gray.) Moluccas (Sluiter, '95:56).

Oreaster linckii (de Blainville). Moluccas (Sluiter, '95:56, as *muricatus*).

Oreaster nodosus (Linnaeus). Bay of Amboina (de Loriol, '93: 380, as *turritus*); Moluccas (Sluiter, '95:56, as *turritus*).

Oreaster sladeni (de Loriol). Moluccas (Sluiter, '95:56).

Oreaster reinhardti Lütken. Ternate (Sluiter, '95:56).

Othilia eridanella Müller and Troschel. Bay of Amboina (de Loriol, '93:391; Döderlein, '96:322; Moluccas (von Martens, '66:85; Sluiter, '95:64). Probably the same as *O. purpurea.*

Othilia purpurea Gray. Amboina (von Martens, '66:60, as *Echinaster fallax;* '67:107, as *purpureus*); Moluccas (Sluiter, '95:64).

* *Paranepanthia platydisca* (Fisher). Buton Strait, Celebes.

Patiriella exigua (Lamarck). Bay of Amboina (de Loriol, '93:384; Moluccas (von Martens, '66:74; Sluiter, '95:59).

**Pectinaster hylacanthus* Fisher. Molucca Passage.

**Pectinaster mimicus* (Sladen). Gulf of Tomini, Celebes; Macassar Strait; Gulf of Boni, Celebes; off Batjan, Moluccas (*Albatross*).

**Pedicellaster chirophorus* Fisher. Gulf of Boni, Celebes.

Pentaceropsis obtusata (B. de St. Vincent). Amboina (de Loriol, '93:381; Döderlein, '96:310); Moluccas (von Martens, '66:82).

**Persephonaster monostoechus* Fisher. Gulf of Tomini, Celebes.

**Persephonaster multicinctus* Fisher. Buton Strait, Celebes.

**Prionaster megaloplax* Fisher. Vicinity of Gillolo, Makyan, and Kayoa, Moluccas.

**Pseudarchaster jordani* Fisher. Molucca Passage.

**Pseudarchaster oligoporus* Fisher. Gulf of Tomini, Celebes.

**Psilaster robustus* Fisher. Batjan Island, Moluccas.

**Pteraster corynetes* Fisher. Molucca Passage.

**Radiaster notabilis* Fisher. Batjan Island, Moluccas; Gulf of Tomini, Celebes.

Retaster insignis Sladen. Amboina (Simpson and Brown, 1910: 60, as *cribrosus*).

Solaster tropicus Fisher. Gulf of Boni, Celebes; Molucca Passage.

Stegnobrisinga placoderma Fisher. Buton Strait, Celebes.

Stellaster belcheri Gray. Amboina (Gray, '47:76).

Stellaster incei Gray. Amboina (Sladen, '89).

**Tarsaster distichopus* Fisher. Strait of Macassar.

* *Xenorias polyctenius* Fisher. Off Makyan, Moluccas.

* *Zoroaster microporus* Fisher. Off Amblan Island (near Bouro Island) Moluccas.

**Zoroaster ophiactis* Fisher. Gulf of Tomini and Buton Strait, Celebes.

LIST OF DREDGING STATIONS AT WHICH STARFISHES WERE SECURED, WITH THE SPECIES TAKEN AT EACH.

Station.	Locality.	Depth.	Nature of bottom.	Bottom temp.	Species taken.
		Fathoms.		*°F.*	
5099	4.8 miles SW. Corregidor Light (14° 18′ 55″ N.; 120° 31′ 20″ E.).	30	Gray mud, sand, shells.	....	*Astropecten velitaris.*
5104	China Sea, off southern Luzon (14° 45′ 48″ N.; 120° 12′ 20″ E.).	33	....	....	*Astropecten phragmorus.*
5109	25.8 miles SW. Corregidor Light (14° 3′ 45″ N.; 120° 16′ 30″ E.).	10	Coral........	....	*Othilia purpurea.*
5111	Balayan Bay, Luzon (13° 45′ 15″ N.; 120° 46′ 30″ E.).	236	....	....	*Astropecten luzonicus, Persephonaster anchistus, Cheiraster inops.*
5112	Balayan Bay, Luzon........	177	Dark-green mud..	52.4	*Astropecten luzonicus.*
5113	.....do........	159	.....do........	....	*Perissogonaster insignis.*
5114	Verde Island Passage, N. coast Mindoro.	340	Fine sand........	....	*Persephonaster habrogenys, Nymphaster meseres.*
5115	.....do........	340	....	....	*Dipsacaster imperialis, Nymphaster meseres.*
5116	Mouth of Balayan Bay, Luzon.	200	....	50.2	*Persephonaster anchistus, Nymphaster mucronatus, Pontroceramus grandis.*
5117	Balayan Bay, Luzon........	118	Dark-green mud..	....	*Paragonaster c. hypacanthus, Anthenoides cristatus.*
5118	.....do........	159	.....do........	....	*Perissogonaster insignis.*
5121	East coast of Mindoro (vicinity Malabrigo Light).	108	Dark-green mud..	....	*Goniopecten asiaticus, Anthenoides cristatus, Anthenoides rugulosus.*
5122	.....do........	220	Green mud........	....	*Cheiraster gazellae, Anthenoides rugulosus.*
5124	Off Pt. Origon, E. coast Mindoro.	281	Soft-green mud....	....	*Zoroaster c. philippinensis.*
5123	.....do........	283	Green mud........	....	*Prionaster analogus, Persephonaster oediplax, Lithosoma penichra, Zoroaster c. philippinensis, Brisingella fragilis.*
5126	Sulu Sea, vicinity southern Panay (10° 48′ N.; 121° 48′ 30″ E.).	742	Soft-green mud....	49.5	*Ctenodiscus orientalis.*
5134	Vic. Basilan Island, Sulu Archipelago.	25	Fine sand........	....	*Astropecten eucnemis.*
5135	11.9 miles NE. of Jolo Light, Jolo (16° 11′ 50″ N.; 121° 08′ 20″ E.).	161	Fine coral sand....	57.4	*Astroceramus sphaeriostictus.*
5136	Off Jolo Light........	20	Sand, shells........	....	*Oreaster alveolatus, Culcita novae-guineae.*
5138	.....do........	19	Sand, coral........	....	*Echinaster callosus.*
5140	.....do........	76	Fine coral sand....	....	*Echinaster stereosomus.*
5141	Off Jolo Light, Jolo........	29	Coral sand........	....	*Oreaster alveolatus.*
5144	.....do........	19	.....do........	....	*Retaster cribrosus.*
5145	.....do........	23	Coral sand, shells..	....	*Culcita n. plana.*
5146	Off Sulade Id., SW. of Jolo..	24	.....do........	....	*Oreaster alveolatus, Fromia eusticha, Anseropoda macropora.*
5147	.....do........	21	.....do........	....	*Ophidiaster tuberifer.*
5149	Off Sirun Id., Tawi Tawi Group.	10	Coral, shells........	....	*Oreaster alveolatus, Asterodiscus helonotus, Acanthaster brevispinus.*
5152	Off Pajumajan Id., Tawi Tawi Group.	34	White sand........	....	*Rosaster nannus.*
5153	Off Pt. Dos Amigos, Tawi Tawi (5° 18′ 10″ N.; 120° 2′ 55″ E.).	49	Coral sand, shells..	....	*Ophidiaster tuberifer.*
5156	Off Tinakta Id., Tawi Tawi Group (5° 12′ 50″ N.; 119° 55′ 55″ E.).	18	Fine sand, shells..	....	*Astropecten phragmorus, Astropecten velitaris, Stellaster incei.*
5157	.....do........	18	Fine sand........	....	*Astropecten phragmorus, Nepanthia maculata, Astropecten velitaris, Luidia longipina, Stellaster incei.*
5158	.....do........	12	Coarse sand, shells.	....	*Astropecten phragmorus, Othilia purpurea, Astropecten velitaris, Luidia prionota, Stellaster incei.*

LIST OF DREDGING STATIONS AT WHICH STARFISHES WERE SECURED, WITH THE SPECIES TAKEN AT EACH—Continued.

Station.	Locality.	Depth.	Nature of bottom.	Bottom temp.	Species taken.
		Fathoms.		*° F.*	
5159	Off Tinakta Id., Tawi Tawi Group (5° 12′ 50″ N.; 119° 55′ 55″ E.).	10	Coral sand........	....	*Astropecten polyacanthus, Fromia japonica, Othilia purpurea, Nardoa lemonnieri, Nardoa frianti, Luidia savignyi, Goniodiscaster forficulatus.*
5160	.....do......................	12	Sand.............	....	*Culcita n. plana, Nardoa tumulosa, Othilia purpurea.*
5161	.....do......................	16	Fine sand, black specks.	....	*Astropecten phragmorus, Nepanthia maculata, Astropecten velitaris, Stellaster incei.*
5163	Off Observation Island, Tawi Tawi Group (5° 01′ 40″ N.; 119° 52′ 20″ E.).	28	Coral sand........	....	*Nardoa frianti.*
5164	.....do......................	18	Green mud........	....	*Othilia purpurea.*
5165	.....do......................	9	Coral.............	....	*Astropecten polyacanthus, Halityle regularis, Luidia aspera, Leiaster analogus, Archaster angulatus, Oreaster alveolatus, Othilia purpurea.*
5166	.....do......................	97	Coral sand........	69.4	*Iconaster perierctus.*
5174	Off Jolo Light, Jolo..........	20	Coarse sand.......	....	*Astropecten polyacanthus, Astropecten vappa inaequalis, Iconaster longimanus.*
5178	Off Pt. Origon, Romblon, 12° 43′ N.; 122° 06′ 15″ E.	78	Fine sand........	....	*Patagiaster sphaerioplax.*
5181	Vic. Antonio Id., off eastern Panay, 110° 36′ 40″ N.; 123° 26′ 35″ E.	26	Mud, fine sand	....	*Astropecten phragmorus, Astropecten monacanthus, Luidia prionota.*
5182	.....do......................	24	Fine sand, mud...	....	*Astropecten velitaris, Astropecten monacanthus, Astropecten eucnemis, Luidia longispina.*
5183	Between Panay and Negros, 10° 32′ 48″ N.; 122° 26′ E.	96	Soft green mud....	63.4	*Zoroaster c. philippinensis.*
5189	Tanon Str., E. coast of Negros	300	Green mud........	62.8	*Luidia gymnochora.*
5197	Off Baliscasag Id., W. Bohol, 9° 52′ 30″ N.; 123° 40′ 45″ E.	174	.....do...........	54.3	*Paragonaster c. hypacanthus.*
5198	.....do......................	220	.....do...........	53.9	*Anthenoides rugulosus.*
5201	Sogod Bay, southern Leyte Id.	554	Gray sand, mud..	52.8	*Ceramaster smithi.*
5207	NE. of Badian Id., off W. Samar.	35	Green mud, sand..	....	*Craspidaster hesperus.*
5208	NW. of Taratara Id., off W. Samar.	26	Soft green mud....	....	*Craspidaster hesperus.*
5209	NE. of Taratara Id., off W. Samar.	20	Green mud........	....	*Craspidaster hesperus, Luidia longispina.*
5212	East of Masbate Id..........	108	Gray sand, mud..	59.9	*Astropecten eucnemis, Anthenoides cristatus, Pholidaster squamatus.*
5214	NE. of Taratara Id., off W. Samar.	218	Green mud........	51.4	*Pholidaster squamatus.*
5215	East of Masbate Id..........	604	.....do...........	50.5	*Sidonaster vaneyi, Persephonaster oediplax, Zoroaster c. philippinensis, Brisinga trachydisca.*
5216	Between Burias and Luzon (off Anima Sola Id.).	215	.....do...........	63.1	*Nymphaster leptodomus, Zoroaster c. philippinensis.*
5217	.....do......................	105	Coarse gray sand..	....	*Coronaster halicepus, Odinia penichra.*
5218	.....do......................	20	Coarse sand.......	....	*Othilia purpurea.*
5219	Between Marinduque and Luzon.	530	Green mud........	....	*Astropecten cremicus, Persephonaster oediplax, Henricia arcystata.*
5226	9.5 miles SW. Corregidor Light, Luzon.	......	....	....	*Coronaster volsellatus.*
5238	E. coast of Mindanao, 9° 43′ N.: 125° 48′ 15″ E.	44	Soft mud.........	....	*Craspidaster hesperus, Astropecten phragmorus.*
5248	Gulf of Davao, Mindanao....	18	Coral.............	....	*Ophidiaster fuscus, Othilia purpurea.*
5249	.....do......................	23	Coral, sand.......	....	*Othilia purpurea.*
5251	.....do......................	20	Coral.............	....	*Fromia japonica, Ophidiaster fuscus.*

LIST OF DREDGING STATIONS AT WHICH STARFISHES WERE SECURED, WITH THE SPECIES TAKEN AT EACH—Continued.

Station.	Locality.	Depth.	Nature of bottom.	Bottom temp.	Species taken.
		Fathoms.		*°F.*	
5252	Gulf of Davao, Mindanao	28	Coral		*Retaster insignis.*
5253	do	28	do		*Oreaster alveolatus, Retaster insignis, Nardoa squamulosa, Ophidiaster fuscus, Othilia purpurea.*
5254	do	21	Sand, coral		*Oreaster nodosus, Oreaster alveolatus.*
5259	Off NW. Panay, vic. Caluya Id.	312	Gray mud, Globigerina.	49.3	*Zoroaster c. philippinensis.*
5260	Off southeastern Mindoro	234	Green mud, sand	51.4	*Anthenoides rugulosus.*
5265	Batangas Bay, Luzon	135	Sand, mud		*Paragonaster c. hypacanthus, Zoroaster c. philippinensis.*
5268	do	170	Sand, pebbles		*Zoroaster c. philippinensis, Astropecten tenellus.*
5272	Off Corregidor Light, Luzon	118	Mud, shells, coral, sand.	57.4	*Ctenophoraster diploctenius, Lithosoma actinometra, Zoroaster c. philippinensis.*
5273	do	114	do		*Paragonaster c. hypacanthus, Zoroaster c. philippinensis, Pontioceramus grandis, Lithosoma actinometra.*
5274	Between Lubang and Luzon, SW. of Manila Bay.	525	Gray mud, sand	41.3	*Ctenodiscus orientalis, Stegnobrisinga placoderma.*
5278	do	102	Fine sand, mud, shells.	59.6	*Zoroaster c. philippinensis.*
5279	do	117	Green mud		*Peltaster cycloplax.*
5280	do	193	Gray sand	49.6	*Calliaster corynetes.*
5281	do	201	Dark gray sand	50.4	*Rosaster mimicus, Coronaster halicepus.*
5282	do	248	do	47.4	*Rosaster mimicus, Zoroaster c. philippinensis.*
5289	Verde Id. Passage, N. coast Mindoro.	172	Broken shells, sand		*Astromesites compactus, Persephonaster e. brevispinus, Paragonaster stenostichus.*
5290	Verde Island Passage, off Batangas Bay, Luzon.	214	Lava gravel		*Persephonaster e. brevispinus.*
5296	do	210	Mud, sand		*Astromesites compactus.*
5297	do	198	Mud, shells		*Persephonaster euryactis, Paragonaster stenostichus, Zoroaster c. philippinensis.*
5298	do	140	Sand		*Zoroaster c. philippinensis.*
5299	do	524	Gray mud, sand		*Zoroaster ophiactis.*
5301	China Sea, vic. Hongkong; 20° 37′ N.; 115° 43′ E.	208	Gray mud, sand	50.5	*Persephonaster anchistus, Persephonaster tenuis, Luidia orientalis, Anthenoides lithosorus.*
5302	China Sea, vic. Hongkong; 21° 42′ N.; 114° 50′ E.	38	Soft gray mud	72.1	*Persephonaster tenuis* (?)
5310	China Sea, vic. Hongkong; 21° 33′ N.; 116° 13′ E.	100	Sand, shells		*Marginaster paucispinus.*
5325	Vic. Hermanos Id., off N. Luzon.	224	Green mud	53.2	*Persephonaster luzonicus, Zoroaster c. philippinensis.*
5326	do	230	Mud	55.4	*Persephonaster luzonicus, Zoroaster c. philippinensis.*
5328	do	150	Blue mud	53.9	*Persephonaster luzonicus.*
5329	do	212	do	51.4	Do.
5332	Mindoro Strait; 12° 37′ 15″ N.; 120° 41′ E.	745	Green mud	38.2	*Koremaster e. spiculatus.*
5335	Linapacan Strait, N. of Palawan Id.; 11° 37′ 15″ N.; 119° 48′ 45″ E.	46	Sand, mud		*Nepanthia maculata.*
5342	Malampaya Sound, Palawan Id.; 10° 56′ 55″ N.; 119° 17′ 24″ E.	14–25	Gray mud		*Astropecten phragmorus.*
5345	do	7	Mud		*Astropecten mindanensis.*
5346	do	7	Mud		*Luidia maculata.*
5348	Palawan Passage; off Pt. Talbonan.	375	Coral sand	56.4	*Cheiraster niasicus, Ceramaster smithi, Craterobrisinga eucoryne, C. analoga.*
5349	do	730	do	40.6	*Pectinaster m. palawanensis, Craterobrisinga eucoryne* (?).
5356	N. Balabac Strait; 8° 06′ 40″ N.; 117° 18′ 45″ E.	58	Sand, shells		*Retaster insignis.*
5357	do	68	Coral sand		*Stellaster incei, Nardoa semiregularis*
5358	Off Sandakan Harbor, Borneo.	39	Mud		*Craspidaster hesperus, Astropecten phragmorus.*

LIST OF DREDGING STATIONS AT WHICH STARFISHES WERE SECURED, WITH THE SPECIES TAKEN AT EACH—Continued.

Station.	Locality.	Depth.	Nature of bottom.	Bottom temp.	Species taken.
		Fathoms.		*°F.*	
5363	Balayan Bay, Luzon	180			*Astropecten luzonicus, Perissogonaster insignis.*
5365	do	214			*Astropecten luzonicus, Persephonaster brevispinus.*
5367	Verde Island Passage; 13° 34′ 37″ N.; 121° 07′ 30″ E.	180	Sand		*Rosaster symbolicus, Anthenoides cristatus.*
5369	NW. of Marinduque Id	106	Black sand		*Anthenoides cristatus.*
5371	do	83	Green mud		*Zoroaster c. philippinensis, Distolasterias euplecta.*
5373	do	338	Soft mud	51.8	*Prionaster gracilis.*
5375		107	Green mud		*Craspidaster hesperus, Anthenoides cristatus.*
5382	Ragay Gulf, Luzon; 13° 15′ 20″ N.; 122° 45′ 30″ E.	128	Mud		*Astropecten granulatus, Anthenoides cristatus.*
5388	Between Burias and Luzon (vicinity Bagatao Light).	220	Soft green mud	51.4	*Cheiraster gazellae, Nymphaster leptodomus, Lithosoma penichra, Zoroaster c. philippinensis.*
5391	Between Samar and Masbate.	118			*Luidia avicularia, Pholidaster squamatus, Coronaster volsellatus.*
5392	do	135	Green mud, sand		*Ctenopleura astropectinides, Pholidaster squamatus.*
5393	do	136	Hard sand		*Astropecten eucnemis, Pholidaster squamatus, Coronaster volsellatus.*
5394	do	153	Green mud		*Anthenoides cristatus.*
5395	do	140	do		Do.
5402	Between Leyte and Cebu	188	Green mud	55.8	*Luidia gymnochora.*
5404	Dupon Bay, Leyte	190	Mud	55.4	Do.
5406	do	298	do		Do.
5409	Between Cebu and Leyte	189	Green mud		Do.
5411	Between Cebu and Bohol	145	do	55.2	*Paragonaster c. hypacanthus, Zoroaster c. philippinensis.*
5412	do	162	do	54.8	*Paragonaster c. hypacanthus, Pontioceramus grandis, Astrothauma euphylacteum, Zoraaster c. philippinensis.*
5415	do	88	Fine sand	62.4	*Distolasterias hypacantha.*
5416	do	150	Green mud	54.4	*Paragonaster c. hypacanthus.*
5417	do	165	Gray mud, sand	54.4	*Paragonaster c. hypacanthus, Zoroaster c. philippinensis, Coronaster volsellatus, Coronaster halicepus, Distolasterias hypacantha.*
5418	do	159	do	54.4	*Zoroaster c. philippinensis.*
5419	do	175	Green mud	54.5	*Paragonaster c. hypacanthus.*
5420	do	127		59	*Anthosticte aulophora, Paragonaster c. hypacanthus.*
5423	Sulu Sea, NW. of Cagayan Id.	508	Gray mud, coral sand.	49.8	*Ctenodiscus orientalis, Dipsacaster diaphorus, Nymphaster habrotatus, Lophaster suluensis.*
5424	Sulu Sea, NE. of Cagayan Id.	340	Coral sand	50.4	*Astropecten pedicellaris, Persephonaster suluensis, Nymphaster habrotatus.*
5425	Sulu Sea, NW. of Cagayan Id.	495	Gray mud, coral sand.	49.4	*Benthogenia cribellosa, Prionaster gracilis, Sphaeriodiscus scotocryptus.*
5426	Sulu Sea, SW. of 30th of June Id.; 9° 12′ N.; 118° 28′ E.	27	Fine gray sand		*Astropecten phragmorus.*
5428	Sulu Sea, SE. of 30th of June Id., 9° 13′ N.; 118° 51′ 15″ E.	1,105	Gray mud	49.7	*Nymphaster atopus, Hymenaster bartschi.*
5431	Sulu Sea, SW. Corandagos Id.; 10° 38′ 45″ N.; 120° 12′ 45″ E.	51	Sand		*Craspidaster hesperus, Metrodira subulata.*
5432	do	51	do		*Rosaster nannus, Stellaster incei, Metrodira subulata.*
5433	do	54	Green mud, coral sand.		*Rosaster nannus, Anseropoda,* sp.
5440	Mouth Lingayan Gulf	172	Fine gray sand, globigerina.	53.2	*Paragonaster c. hypacanthus, Astrostephane acanthogenys.*
5444	North coast of Samar	308	Green mud	45.3	*Pectinaster hylacanthus.*
5445	do	383	Green mud, sand	44.3	*Dipsacaster diaphorus, Pectinaster hylacanthus, Cheiraster inops, Cheiraster niasicus.*
5447	Lagonoy Gulf, E. coast Luzon	310	Green mud	45.3	*Cheiraster niasicus.*
5450	do	408	Green mud, coral	42.3	*Mediaster ornatus.*

LIST OF DREDGING STATIONS AT WHICH STARFISHES WERE SECURED, WITH THE SPECIES TAKEN AT EACH—Continued.

Station.	Locality.	Depth.	Nature of bottom.	Bottom temp.	Species taken.
		Fathoms.		*° F.*	
5453	Albay Gulf	146			*Astropecten tenellus, Zoroaster c. philippinensis.*
5454	do.	153			*Anthenoides cristatus.*
5460	Lagonoy Gulf, E. coast Luzon.	565	Gray mud		*Ctenodiscus orientalis, Psilaster gotoi, Atelorias anacanthus.*
5467	do.	480	Green mud		*Pectinaster hylacanthus, Mediaster ornatus.*
5468	do.	569	do.		*Psilaster gotoi.*
5470	do.	560	Mud		*Ctenodiscus orientalis, Psilaster gotoi.*
5476	San Bernardino Strait; 12° 56′ 24″ N.; 124° 25′ 24″ E.	270	Fine sand	48.3	*Tritonaster evorus, Zoroaster c. philippinensis.*
5478	NE. Tacbuc Pt., Leyte	57	Shells		*Nepanthia joubini.*
5480	do.	62	Fine sand		*Astropecten velitaris, Astropecten monacanthus.*
5481	Surigao Strait, E. of Leyte	61	Sand, shells, gravel		*Astropecten monacanthus, Rosaster mamillatus, Asterodiscus elegans.*
5482	do.	67	Sand, green mud, shells.		*Goniodiscaster forficulatus, Asterodiscus elegans, Ophidiaster trychnus, Ophidiaster dubiosus, Nardoa squamulosa, Asterinopsis pedicellaris.*
5483	do.	74	Sand, broken shells		*Stellaster incei, Echinaster stereosomus, Pteraster o. myonotus.*
5487	Between Leyte and Mindanao; 10° 02′ 45″ N.; 125° 05′ 33′ E.	732	Green mud	52.3	*Brisinga trachydisca.*
5488	Between Leyte and Mindanao; 10° N.; 125° 06′ 45″ E.	772	do.	52.3	Do.
5491	Between Leyte and Mindanao: 9° 24′ N.; 125° 12′ E.	736	Green mud, coral	52.3	*Sidonaster vaneyi, Astropecten eremicus, Nymphaster habrotatus, Brisinga trachydisca.*
5492	Between Leyte and Mindanao; 9° 12′ 45″ N.; 125° 20′ E.	735	Green mud	52.1	*Astropecten eremicus.*
5494	Between Leyte and Mindanao; 9° 06′ 30″ N.; 125° 18′ 40″ E.	678	Green mud, sand	53.3	*Astropecten eremicus, Brisinga trachydisca.*
5499	Mindanao Sea, vic. Iligan Bay	554	Green mud, fine sand.	52.3	*Ctenodiscus orientalis.*
5501	do.	214	Fine sand, gray mud.	54.3	*Anthenoides rugulosus.*
5503	do.	226	Green mud	53.3	*Anthenoides rugulosus.*
5505	do.	220			*Anthenoides cristatus.*
5510	Iligan Bay, N. coast Mindanao.	423	Gray mud, fine sand.	53.0	*Lithosoma penichra, Henricia densispina.*
5512	do.	445	do.	52.8	*Cheiraster diomedeae.*
5513	do.	505	do.	52.8	*Benthogenia cribellosa.*
5515	do.	700+	(No sounding)		*Brisinga trachydisca.*
5516	Mindanao Sea, off Pt. Tagolo, Mindanao.	175	Globigerina	51.3	*Nymphaster euryplax, Anthenoides cristatus.*
5517	do.	169	do.	51.3	*Henricia densispina.*
5518	do.	200	Gray mud, globigerina.	54	*Astropecten tenellus, Henricia microplax, Pteraster o. myonotus.*
5519	do.	182	Globigerina, sand.	54.3	*Henricia densispina.*
5520	do.	102		61.3	*Ctenopleura astropectinides, Rosaster symbolicus, Anthenoides cristatus.*
5523	do.		No sounding		*Astroceramus lionotus, Henricia densispina, Pteraster o. myonotus*
5524	do.	360	Sand	52.8	*Henricia densispina.*
5526	Between Siquijor and Bohol Is.	805	Green mud, globigerina.	52.3	*Dipsacaster diaphorus.*
5527	do.	392	Globigerina ooze	53.3	*Ctenodiscus orientalis, Anthenoides rugulosus, Zoroaster c. philippinensis.*
5528	do.	439	do.	53.3	*Ctenodiscus orientalis, Dipsacaster diaphorus, Lithosoma penichra, Zoroaster c. philippinensis.*
5529	do.	441	Gray mud, globigerina.	53	*Ctenodiscus orientalis.*

LIST OF DREDGING STATIONS AT WHICH STARFISHES WERE SECURED, WITH THE SPECIES TAKEN AT EACH—Continued.

Station.	Locality.	Depth.	Nature of bottom.	Bottom temp.	Species taken.
		Fathoms.		*° F.*	
5536	Between Negros and Siquijor	279	Green mud	53.5	*Nymphaster dyscritus*, *Anthenoides cristatus*, *Anthenoides rugulosus*, *Henricia densispina*, *Henricia arcystata*, *Pteraster o. myonotus.*
5537	do	254	do	53.5	*Prionaster analogus*, *Perissogonaster insignis.*
5538	do	256	Green mud, sand	53.3	*Cheiraster gazellae*, *Zoroaster c. philippinensis.*
5541	Mindanao Sea, off Pt. Tagolo, Mindanao.	219	Fine sand, broken shells.	53.3	*Prionaster analogus*, *Nymphaster dyscritus.*
5543	do	162	Sand	54.5	*Tarachaster tenuis.*
5549	SW. of Jolo Light, Jolo	263	Sand, globiginera, for aminifora.	52.3	*Hymenasterides zenognathus.*
5550	do	258	Fine sand, shells	52.3	*Persephonaster e. brevispinus*, *Hymenasterides zenognathus*.
5555	SE. of Cabalian Pt., Jolo	34	Coarse sand		*Nardoa tumulosa.*
5558	N. of Cabalian Pt., Jolo	15	Coral		*Linckia laevigata.*
5565	Between Jolo and Tawi-Tawi, 5° 51′ 42″ N.; 120° 30′ 30″ E.	243	Sand, pteropod shells.	52.3	*Zoroaster c. philippinensis.*
5582	Vicinity of Darvel Bay, Borneo.	890	Gray mud, fine sand.	38.3	*Pseudarchaster jordani*, *Zoroaster ophiactis*, *Cnemidaster wyvillii.*
5585	Sibuko Bay, Borneo	476	Gray mud	41.1	*Ctenodiscus orientalis.*
5586	do	347	do	44	*Ctenodiscus orientalis*, *Pseudarchaster jordani.*
5587	do	415	Green mud, sand, coral.	42.3	*Ctenodiscus orientalis*, *Pseudarchaster jordani*, *Zoroaster c. philippinensis.*
5589	do	260	Fine gray sand, gray mud.	45.7	*Zoroaster c. philippinensis.*
5592	do	305	Green mud	43.3	*Persephonaster habrogenys.*
5601	Gulf of Tomini, Celebes; 1° 13′ 10″ N.; 125° 17′ 05″ E.	765	Sand, globigerina, pteropods.		*Koremaster evaulus.*
5602	Gulf of Tomini, Celebes; 0° 22′ N.; 132° 03′ 30″ E.	962	Gray mud		*Cnemidaster wyvillii.*
5605	Off Dodepo Id., Gulf of Tomini, Celebes.	647			*Ctenodiscus orientalis*, *Psilaster* sp., *Radiaster notabilis*, *Myxaster medusa.*
5606	do	834	Green mud		*Persephonaster monostoechus*, *Koremaster evaulus*, *Hymenaster rhodopeplus*, *Zoroaster ophiactis.*
5607	Off Binang Unang Id., Gulf of Tomini, Celebes.	761	Fine sand		*Pectinaster mimicus*, *Cnemidaster wyvillii.*
5608	do	1,089	Gray sand	36.3	*Pectinaster mimicus*, *Pseudarchaster oligoporus*, *Cnemidaster wyvillii.*
5609	do	1,092	Green mud	36.3	*Pectinaster mimicus*, *Pseudarchaster oligoporus.*
5617	N. E. Ternate Id., 0° 49′ 30″ N.; 127° 25′ 30″ E.	131			*Dissogenes styracia.*
5618	Molucca Passage	417	Gray mud		*Ctenodiscus orientalis*, *Cheiraster niasicus*, *Benthopecten moluccanus*, *Pseudarchaster jordani.*
5619	do	435	Fine gray sand, mud.		*Ctenodiscus orientalis*, *Pectinaster hylacanthus*, *Cheiraster niasicus*, *Benthopecten moluccanus*, *Solaster tropicus.*
5621	Vicinity of Makian Id., Molucca Is.	298	Gray and black sand.		*Coronaster halicepus.*
5622	do	275	Gray mud		*Nymphaster moluccanus*, *Anthenoides granulosus*, *Xenorias polyctenius*, *Hymenasterides zenognathus.*
5623	do	272	Fine sand, mud		*Dipsacaster nesiotes*, *Pteraster corynetes*, *Hymenasterides zenognathus.*
5624	do	288	do		*Prionaster megaloplax*, *Dipsacaster nesiotes*, *Cheiraster niasicus*, *Anthenoides granulosus.*
5625	Between Gillolo and Kayoa Is., Moluccas.	230	Gray mud, fine sand.		*Prionaster megaloplax*, *Nymphaster moluccanus.*

LIST OF DREDGING STATIONS AT WHICH STARFISHES WERE SECURED, WITH THE SPECIES TAKEN AT EACH—Continued.

Station.	Locality.	Depth.	Nature of bottom.	Bottom temp.	Species taken.
		Fathoms.		° *F.*	
	Between Gillolo and Kayoa Is., Moluccas.	230	Gray mud, fine sand.	....	
5626	.....do........................	265	.....do............	....	*Cheiraster niasicus, Anthenoides granulosus, Astrostephane moluccana.*
5630	S. of Patiente Strait; 0° 56′ 30″ S.; 128° 05′ E.	569	Coral sand, mud..	....	*Pectinaster mimicus, Radiaster notabilis, Pedicellaster* sp.
5631	S. of Patiente Strait; 0° 57′ S.; 127° 56′ E.	809	Green mud........	....	*Psilaster robustus.*
5632	Off Batjan Id.; 1° S.; 127° 50′ E.	845	....	....	*Psilaster robustus.*
5637	Vicinity Amblan Id., off S. E. Bouro; 3° 53′ 20″ S.; 126° 48′ E.	700	Gray mud........	....	*Zoroaster microporus.*
5640	Buton Strait, Celebes........	24	Sand, shells.......	....	*Ferdina glyptodisca.*
5641	.....do........................	39	.....do............	....	*Ophidiaster fuscus.*
5645	.....do........................	206	....	....	*Paranepanthia platydisca.*
5648	.....do........................	559	Green mud........	39.2	*Persephonaster multicinctus, Aphroditaster microceramus, Nymphaster arthocnemis, Zoroaster ophiactis, Bythiolophus acanthinus, Brisingenes mimica, Brisingenes anchista, Astrostephane moluccana, Stegnobrisinga placoderma.*
5651	Gulf of Boni, Celebes........	700	.....do............	38.7	*Cheiraster triplacanthus, Nymphaster arthrocnemis, Crossaster scotophilus.*
5654	.....do........................	805	....	38.3	*Pectinaster mimicus, Benthopecten polyctenius, Solaster tropicus.*
5655	.....do........................	608	Gray mud, fine sand.	39.2	*Atelorias anacanthus.*
5656	.....do........................	484	Gray mud........	41.2	*Ctenodiscus orientalis, Diplopteraster m. patagiatus, Pedicellaster chirophorus.*
5658	.....do........................	510	.....do............	41.2	*Cheiraster niasicus.*
5660	Flores Sea; 5° 56′ 30″ S.; 120° 49′ E.	692	Gray mud, sand..	39.2	*Pectinaster mimicus, Cheiraster ludwigi.*
5664	Macassar Strait; 4° 43′ 22″ S.; 118° 53′ 18″ E.	400	Hard...............	43.3	*Tarsaster distichopus.*
5668	Macassar Strait; 2° 28′ 15″ S.; 118° 49′ E.	901	Gray mud........	38.2	*Pectinaster mimicus, Benthopecten styracius, Freyellaster spatulifer.*

DESCRIPTION OF SPECIES.

Family PORCELLANASTERIDAE Sladen, restricted.[1]

Genus SIDONASTER Koehler.

Sidonaster Koehler, 1909, p. 37.—Fisher, 1911*d*, p. 23.

SIDONASTER VANEYI Koehler.

Plate 3, fig. 3.

Sidonaster vaneyi Koehler, 1909, p. 37, pl. 3, fig. 6; pl. 6, fig. 5; pl. 10, fig. 3.

Diagnosis.—R = 36 mm.; r = 15 mm.; R = 2.4 r (Koehler's type R = 2 r). Abactinal integument of disk covered with small spinelets as far as distal edge of cribriform organ, that of rays being bare; superomarginals 5 to 7 with one upright spine and 1 or 2 smaller accessories; terminal plate with 7 spines; adambulacral spinules 1 or 2, usually 2, the plates strongly hollowed on furrow margin; mouth plates with a median unpaired spinule, and spaced from this 2, 3, or rarely 4 marginal spinules at mouth of furrow.

Notes on Philippine specimens.—The 4 specimens combine certain characters of *S. vaneyi* and *S. batheri*. It has in fact been difficult to decide what to name them. The two specimens from station 5215 are much larger than Koehler's specimens of either *vaneyi* or *batheri*, since the type of *vaneyi* has R = 20 mm., and that of *batheri* not more than 26 mm. Koehler has so carefully described both species that I shall need only to point out the differences presented by the Philippine examples.

The abactinal spinelets do not extend quite so far distally on the radii as figured by Koehler. Two large specimens from station 5215 vary in this respect, one being about intermediate between the condition of typical *vaneyi* and *batheri*. Along the edges of the abactinal integument the spinelets extend to the distal edge of the cribriform organ, but on the radial line little if any farther than an intersecting line drawn between the middle of two adjacent cribriform organs. Thus the spinous and papular area is deeply concave radially, and the varying amount of this concavity (even on different radii of the same specimen) controls the width of the interradial band of abactinal spinelets. Abactinal spinelets are as described by Koehler, and 1.5 mm. long.

---

[1] As noted under the Goniopectinidae, the Ctenodiscinae are more properly referable to that family. Fisher, 1916*a*, p. 1.

There are 7 superomarginal and 8 or 9 inferomarginal plates on the largest specimens, and 7 of each on two smaller examples from station 5491. The cribriform organ is relatively larger in the larger specimens. The spinelets of each distal border, to the number of about 20, are united by a thin membrane, but the others are free. The angle between the lateral and ventral border is more abrupt in the large specimens, possibly because the organ occupies a larger amount of the first plate, there being scarcely any of it left bare. Koehler found 5 marginals in the type. In *batheri* there are 5 to 7. The superomarginals nearly always have a second or accessory spinule, and on the second and third plate, sometimes elsewhere, 2 accessories. One of the smaller specimens has 3 on the second plate. The primary spines are more prominent in small than in large examples. The spines of the terminal plate are as described by Koehler.

Large examples have 15 (instead of 11 of the type) pairs of adambulacral plates and 15 pairs of tube feet to each ray. The adambulacral plates are hollowed out on the furrow margin as described by Koehler, but instead of there being constantly 2 furrow spinules, a few proximal plates have only 1; in one of the large specimens the 6 or 7 distal plates have only 1 spinule. This same specimen has 2 spinules to each mouth plate, in addition to the median unpaired marginal spine, but the other large specimen has 3 on all plates except one, where there are 4. The 2 small specimens have usually 3 lateral mouth spines, occasionally 4. The type of *vaneyi* has 2, and *batheri* has 4 or 5. The mouth plates are very prominent actinally and each is produced into a winglike process adjacent to first adambulacral.

The plates of the actinal intermediate areas are rather loosely joined, some of them slightly imbricated. About 30 of the plates bear a central slender spinelet, very similar to the spinelets of the cribriform organs, although a trifle longer. The median interradial area is not devoid of spinelets as in *S. psilonotus*. The intermediate plates extend to the fifth or sixth adambulacral plate.

The peristome contains widely scattered microscopic rods with a few perforations. These are more numerous in the lip. A small piece of the wall of the stomach did not have any calcareous deposits. A piece of the dorsal integument from the ray (where there were neither papulae nor spinelets) contained scattered microscopic plates, some very small with 2 or 3 perforations, and apparently just beginning to be formed; others larger and with very irregular periphery; still others nearly circular with 12 to 25 perforations.

Type-locality.—Gulf of Oman, lat. 21° 53′ N.; long. 57° 43′ E., 833 to 733 fathoms (Koehler).

Distribution.—Gulf of Oman and Philippine Islands 733 to 833 fathoms, green mud.

Specimens examined.—Four from the following localities:

Station 5215, east of Masbate Island, Philippine Islands, 604 fathoms, green mud; bottom temperature 50.5° F.; 2 specimens.

Station 5491, between Leyte and Mindanao, Philippine Islands, 736 fathoms, green mud, coral; bottom temperature, 52.3° F.; 2 specimens.

Remarks.—This species differs from *S. psilonotus* in having abactinal spinelets, 7 instead of 5 spines on the terminal plate, and usually 2 or 3 lateral mouth spines instead of 4, although the number of 4 sometimes occurs.

One of the small specimens from station 5491 has the stomach full of mud. There is also a relatively large *Dendrogaster* parasitic in the coelomic cavity.

SIDONASTER PSILONOTUS Fisher.

Plate 1, figs. 2, 3; plate 7, fig. 2.

Sidonaster psilonotus FISHER, 1913*a*, p. 600.

Diagnosis.—Rays 5. R=22 mm.; r=11 mm.; R=2 r; breadth of ray at distal edge of cribriform organ, 7 mm.; width of cribriform organ 6.5 mm.; height interradially, 4 mm. Differing from *S. vaneyi* and *S. batheri* in the almost entire absence of abactinal spinelets. Adambulacral spinules 2; mouth spinules, 1 unpaired and 4 marginal; terminal plate with 5 spinules.

Description.—The rays are only slightly tapered and have a blunt extremity capped by a prominent spiniferous terminal plate. Marginal plates forming a prominent beveled or sloping border to abactinal surface. Abactinal integument on rays slightly and on disks markedly sunken below upper edge of marginal plates, and devoid of spinelets except for about 20 to 24, scattered close to each cribriform organ, and not extending distally beyond the edge of this organ. Spinelets about as long as those on surface of cribriform organ. Papulae numerous, prominent, and occupying a pentagonal area, the corners of which touch the middle of each cribriform organ. They do not therefore extend onto the rays. There is a prominent apical prolongation of the integument in center of disk, but the papulae do not extend upon it. The abactinal integument contains spaced, microscopic, perforated calcareous plates, roundish or irregular in outline, sometimes with a few short spines on the periphery. These plates resemble end plates in the pedicels of holothurians, and seem to consist of one layer of reticulum except that the center is often slightly thickened. Madreporic body large, touching cribriform organ, convex and traversed by coarse ridges radiating from a point between the center and adcentral edge. A few spinelets surround it.

Marginal plates thin, the superomarginals the higher. Second superomarginal about as long as high, but the succeeding four are longer than high, and the seventh or last about as long as high. Each bears on the upper distal corner a slender, prominent, sharp spinule usually bent transversely across the smooth abactinal integument. The second plate has a shorter companion spinule. The longest spinule (2 mm.) is on the fifth plate.

Inferomarginal plates conspicuously lower than superomarginals and hence proportionately longer than high. Second plate corresponding to second superomarginal is shorter than the rest. These plates do not encroach upon actinal surface. No spines.

Cribriform organs very prominent, wider than high, with slightly convex upper border, and leaving only a very narrow bare area on distal edge of the plates. The organs comprise therefore practically all the surface of each interradial pair of supero- and inferomarginal plates. The spinelets are blunt, slender, very uniform in size, and arranged in vertical series. Those of the first or marginal vertical series are webbed. No others are.

Terminal plate prominent, crescentiform, the rounded sides covering the edges of the last marginals. There are 5 terminal, prominent, sharp spinules; 3 of these form a triangle in the end of plate, surrounding the terminal papilla, and one stands laterally on the upper edge of plate.

Adambulacral plates longer than wide and with a concave margin. Each plate bears at the adoral end 2 sharp marginal spinules sometimes slightly curved and compressed at base, these occupying about half the furrow margin of each plate.

Mouth plates very prominent actinally, the free surface sloping steeply to median suture, which is wide and lanceolate in form. Each pair of plates bears an unpaired spine at the inner angle where the 2 plates join, and widely spaced from this, 4 tapering, sharp, marginal spines are borne on the concave margin opposite the first tube foot.

Actinal intermediate areas moderate, the plates loosely joined in irregular interradial columns. Six to 8 of the plates on either side of the double interradial series bear a single spinelet similar to those of cribriform organ.

Tube feet large, without calcareous particles in the walls. Dorsal wall of the stomach with numerous simple, straight, rather large microscopic rods, with occasional irregular and Y-shaped ones. The length of these rods varies about as the diameter of the plates in the dorsal integument.

Type.—Cat. No. 30504, U.S.N.M.

Type-locality.—Unknown.

Remarks.—It is unfortunate that this new form should be without locality It differs from *S. vancyi* in lacking abactinal spinelets, in having 5 instead of 7 terminal spines, in the spinulation of the actinal interradial areas, and in having constantly 4 (instead of 2, 3, or rarely 4) mouth spines. It differs from *S. batheri* in lacking abactinal spinelets, and in having 5 instead of 7 terminal spines.

Genus BENTHOGENIA Fisher.

Benthogenia FISHER, 1911*c*, p. 415. Type, *B. cribellosa* Fisher.

Diagnosis.—Related to *Hyphalaster* Sladen and *Thoracaster* Sladen, but differing in having cribriform organs between *all* the marginals, in having the dorsal surface of distal half of ray one continuous cribriform organ, and in having the cribriform organs of interbrachium merged into one. Distal superomarginals spiniferous; terminal plate large, spiniferous, dorsal in position. No odd interradial marginal. Superomarginals increasing in size very gradually to the sixth, which is considerably larger than the rest and meets its fellow in median line of ray; beyond this point all superomarginals in contact. Cribriform organs 29 or 30, the distal ones rudimentary and the 11 of the interbrachium merged into one (as far as middle of sixth superomarginal); structure papilliform. Adambulacral plates with a numerous furrow series and numerous smaller spinelets on surface. Actinal interradial areas extensive, covered with small spaced spinelets. Intermediate plates extend nearly to end of ray. Abactinal paxillae large, crowded.

BENTHOGENIA CRIBELLOSA Fisher.

Plate 1, fig. 1; plate 2, fig. 1; plate 8, figs. 2, 2*a–d*.

Benthogenia cribellosa FISHER, 1911, p. 415.

Description.—Rays 5. R=78 mm., r=about 30 mm., R=about 2.6 r; breadth of ray at base, about 34 mm., at sixth superomarginal, 12 mm. Over half of ray formed by superomarginals which meet in median line. Superomarginals massive, increasing in size from the first to sixth, which is decidedly larger than the rest and meets its fellow on dorsal median line; next 6 plates decreasing slightly in width, but increasing in height as far as terminal plate. Each is higher than wide, and bears on the rounded dorsolateral angle a stubby conical spine; final 3 or 4 plates decreasing rapidly in size and covered by the big, elliptical, very convex spiniferous terminal plate, margined by a fimbriate channel. Inferomarginals lower than superomarginals and beyond the sixth plate not corresponding to them, but near tip of ray alternating, there being one more in the series. Each inferomarginal has a low tubercle corresponding to the superomarginal spine. Viewed from side, both series increase in height from interradius to the sixth plate; thence the superomarginals increase slightly in height up to the terminal plate, while the inferomarginals decrease. Beyond the sixth plate the inferomarginals do not encroach upon the actinal surface. The horizontal suture between the two series is not deep. The free surface of the plates is covered with minute bosses.

Terminal plate very convex, large, elliptical, and wholly dorsal in position, as it lies over the last three superomarginal plates. Judging from the scars of the spines, there are 4 terminal spines placed symmetrically, 2 on either side, and on the narrow summit of the plate, behind these, a series of 3 spines, making 7 in all.

Cribriform organs spiniform and in the interbrachial arc, continuous without a break as far as the middle of the sixth or enlarged superomarginals, except for a slight wedge-shaped area in the middle of the lower edge of each inferomarginal. In each interbrachium 11 fused cribriform organs, the odd one over the median interradial suture. The sixth supero- and inferomarginals have a median vertical bare space about as wide as the adjacent cribriform organs, which from here on rapidly narrow, and from the twelfth plate on may be said to be rudimentary. These separated cribriform organs extend upon the dorsal surface of ray and fuse with those of opposite side so that the whole area from the limit of paxillae to terminal plate and between the two dorsal rows of spines is a thick continuous mat of spinelets, absolutely identical with the lateral cribriform organs, and a fimbriate channel leads on either side from this area along the lower edge of the terminal plate. The total number of lateral organs is: Rays 9+9+interbrachium 11=29. This varies to 30, as some rays have an additional small one at tip. The distal organs are of course rudimentary. The delicate mostly terete spinelets end in a blunt or even capitate fleshy tip (the calcareous part being truncate denticulate). They are very close-set, in regular quincunx, and decrease in length distad, markedly beyond the sixth marginal. The spinelets of the vertical marginal series, in the separated organs are flattened and united by a continuous web; all other spinelets free and independent.

Paxillar areas with a stellato-penatagonal contour and comprising the disk and proximal third of ray. Paxillae large, fairly high, crowded, those on rays largest, decreasing in size toward center of disk. The larger paxillae have 15 to 20 peripheral and 5 to 15 central spinelets, cylindrical and slightly knobbed at tip, and one-third to one-half as long as shaft of paxilla, which is variable in thickness but elliptical in section. The bases of paxillae are also elliptical, slightly spaced, and independent. Papulae about 8 surrounding a plate; absent from a narrow midradial area.

Adambulacral plates longer than wide with 7 or 8 compressed, basally webbed furrow spines on a curved margin, and on surface of plate 10 to 12 much shorter spinelets, similar to the actinal intermediates, in about two series. Furrow very narrow.

Mouth plates prominent and with wide suture. Marginal spines 12, the innermost abruptly enlarged into a flattened conspicuous lanceolate tooth, the others subsimilar to adambulacrals. Suborals about 15 to a plate, in two series, small except inner two, which form a series just back of the teeth.

Actinal intermediate areas extensive, the plates slightly imbricated with rounded margin toward center. The rather triangular, broad, interradial area has its outer angle about at the sixth marginals, whence the plates extend in a narrow and tapering band to within about 4 inferomarginals of end. Plates beset with spaced, short, more or less clavate spinelets, increasing in length toward margin. A plate near center of area has 6 to 10, sometimes as many as 12, spinelets. Others near periphery have 5 or 6.

Madreporic body situated a little more than its own diameter from margin, traversed by striae proceeding from a point near the adcentral margin, and bearing many little blunt spiniform protuberances resembling the tips of paxillar spinelets.

Young.—There are 3 young specimens from station 5425, 2 of which were recovered from the stomach of *Prionaster gracilis*. I am not at all sure that these belong to this species. They are young of *Benthogenia*, although some of the generic characters are not yet full-fledged. The smallest of the three has R 5.5 mm. and 4 marginal plates to the ray in each series; the largest has R 12 mm., and 10 superomarginals, which, from the sixth on meet their neighbors along the midradial line, as in the adult. A few notes on the latter specimen are appended.

Rays short, less pronounced than in adult, abactinal paxillae with 4 or 5 spinelets, and a little more uniform in size than in type. Margin of rays and disk rounded, the sixth superomarginal not enlarged. Terminal plate large, but ovoid, and as broad as long, with only 4 spines, 3 terminal, and 1 dorsal. Cribriform organs not confluent in the interbrachium, but with a bare space as wide or slightly wider than adjacent organs on each plate. Spinelets relatively large, and in the median interbrachial organ in 6 vertical series, with 6 to 8 in each series. The 2 marginal vertical series of each organ webbed. Beyond fifth marginal the organs are reduced to simple fimbriate channels. The median radial cribriform organ so characteristic of the adult is indicated only in a fimbriate channel between the 2 series of superomarginal plates. One or 2 superomarginals have a special dorsal spine.

The epiproctal peduncle is prominent, and there is certainly a tiny pore at the summit. Whether this is confined to immature life can not be determined.

Actinal intermediate areas with well-spaced, small spinelets. Adambulacral plates longer than wide with a palmate series of 5 flattened pointed furrow spinelets disposed along the obtusely angular margin, and basally webbed. Subambulacral spinelets, small, 1 or 2, or absent. Mouth plates with 8 marginal spinelets; suborals few, rudimentary.

These young specimens resemble the genus *Hyphalaster*, more especially *H. hyalinus* Sladen. They differ from this genus, however, in having cribriform organs between all the marginals. Hence the number of organs is determined by the number of marginals. It is important to note that a certain strongly marked character of the adult, and one which is believed to be generic, is only partly developed in these immature examples. I refer here to the peculiar distribution of the cribriform organs, which in the interbrachium are fused into one in the adult, and also occupy the dorsal radial area of the distal portion of ray. In the adult the terminal plate is entirely dorsal to the superomarginals but in the young only the proximal half overlies the distal superomarginals.

With only the young specimens, it would not be possible to correctly diagnose the genus *Benthogenia*. Since several species of *Porcellanaster* have been named from very immature types, it is probable that the adults will be difficult to identify correctly.

Type.—Cat. No. 28655, U.S.N.M.

Type-locality.—Station 5513, Iligan Bay, northern Mindanao, lat. 8° 16′ 45″ N.; long. 124° 02′ 48″ E.; 505 fathoms, bottom temperature 52.8° F., gray mud and fine sand.

Distribution.—Mindanao Sea and Sulu Sea, Philippine Islands.

Specimens examined.—The type, and three immature from station 5125, Sulu Sea, near Cagayanes Islands, 495 fathoms, gray mud, coral sand, bottom temperature 49.4° F.

Remarks.—As indicated in the diagnosis, the genus *Benthogenia* is distinguished by the possession of an indefinite number of cribriform organs, these being present between all the marginals, by the fusing of the cribriform organs of the interbrachium, by the presence of a curious dorsal cribriform organ on the surface of those superomarginals which unite in the median line of ray, and by an entirely dorsal spiniferous prominent terminal plate. The genus probably stands nearest *Hyphalaster*, although resembling *Thoracaster* in the abundance of actinal intermediate spinelets. The structure of the adambulacral, mouth, marginal and terminal plates is near that of *Hyphalaster*. *Benthogenia* might be described as a *Hyphalaster* having cribriform organs between all the marginals, and a dorsal cribriform organ on the distal portion of ray. The last, I believe, is not found in any other genus, nor does any genus of the Porcellanasteridae have cribriform organs of an indefinite and large number.

The genus *Lysaster* Bell[1], the type of which I have had the privilege of examining, seems to me to be a near relative of *Thoracaster*. The actinal intermediate plates have numerous short, sharp spines, and the adambulacral plates 4 sharp furrow and about 3 shorter sharp subambulacral spines. There are 7 cribriform organs to each interradius, which extend ventrally nearly or quite to the inner edge of the inferomarginals, the intermediate bare area being equal to the width of the organ. There are no cribriform organs on the ray, the most distal one being on the adoral margin of the first superomarginals that meet medially. There are 10 or 11 superomarginals and the large terminal plate, overlying the 2 last superomarginals of each series, has 3 large spines. On each series of superomarginals of the ray only are 1 or 2, usually 2, stout dorsal acute spines—thus 3 or 4 to a ray. The paxillae are astropectinoid, well developed, and the madreporic body is close to the margin, exposed, and a little broader than width of exposed portion of superomarginal.

Family GONIOPECTINIDAE Verrill, emended.

Goniopectinidae VERRILL, 1889, p. 213.—FISHER, 1911*d*, pp. 17, 22; 1916*a*, p. 2.

Diagnosis.—Specialized fascioles or cribriform organs between all the marginal plates; actinal plates in double transverse series, there being between every pair a specialized fasciolar channel, roofed by webbed spinelets, leading from the marginal fascioles to the furrow; ampullae single; superambulacral plates present; abactinal skeleton astropectinoid.

Remarks.—In Asteroidea of the North Pacific and Adjacent Waters (Fisher, 1911*d*, p. 19) the family Goniopectinidae, proposed by Prof. A. E. Verrill, was said to differ from the Porcellanasteridae in having double ampullae connected with the tube feet, and in having an intestine and intestinal coecum. The component genera of the Goniopectinidae, *Goniopecten* and *Prionaster*, bear the closest resemblance to *Ctenodiscus* which has always heretofore been regarded as one of the Porcellanasteridae. This resemblance results from the similar characteristic biserial arrangement of the skin-covered actinal plates with the intervening fasciolar channels, the similar structure of the marginals, between which are cribriform organs, and the similar form and armature of the adambulacral and mouth plates.

---

[1] Report on the Echinoderma collected by Mr. J. Stanley Gardiner in the Western Parts of the Indian Ocean. Trans. Linn. Soc. London, ser. 2, vol. 13, Zoology, October, 1909, p. 21, pl. 3, *Lysaster lorioli*. By a lapsus Professor Bell placed this genus in the Goniasteridae. The plate shows its cribriform organs and Porcellanasterid habit.

All species of *Goniopecten* and *Prionaster*, however, have single ampullae, thus eliminating the principal supposed difference between these genera and *Ctenodiscus*. What I formerly regarded as the lower lobe of the ampulla in *Prionaster* proves to be only a swelling probably due to the extreme contraction of the muscular vesicles. If the swelling has any significance at all, it is the merest rudiment of a ventral lobe and the ampullae are to be regarded as single. This fact seems to make it advisable to unite the three genera in a single family which would be separated from the Porcellanasteridae proper by the presence of cribiform organs between all the marginals,[1] by the actinal fascioles, and by the presence of superambulacral plates. Although an apical pore may be present in *Ctenodiscus*, I have also dissected specimens in which I could find no trace of an opening, nor of a tubular connection between the stomach and the "epiproctal cone." In the middle of the dorsal side of the stomach there is a roundish lobe of small size which may represent the degenerated rudiment of a coecum. *Prionaster elegans*, on the other hand, has a fairly large, butterfly-shaped coecum, connected with the apical pore by a definite tubule. *P. megaloplax* has a conspicuous "anal" aperture. This difference between *Prionaster* and *Ctenodiscus* must be weighted against the important common characters mentioned above, and stated in the diagnosis of the family. On account of its more Porcellanasterid characters *Ctenodiscus* may well come first in the family. Presumably *Pectinidiscus* belongs here also, paralleling the characters of *Prionaster*.

Subfamily CTENODISCINAE Sladen.

Diagnosis.—Marginal cribriform organs consisting of superimposed transverse webbed combs of spinelets: intestinal coecum obsolete; no intestine.

Genus CTENODISCUS Müller and Troschel.

Ctenodiscus Müller and Troschel, 1842, p. 76. Type, *Asterias crispata* Retzius.

CTENODISCUS ORIENTALIS Fisher.

Plate 2, figs. 2–4; plate 7, figs. 1, 1*a*–*e*.

Ctenodiscus orientalis Fisher, 1913*a*, p. 601.

Diagnosis.—Differs from *Ctenodiscus crispatus* in having longer and relatively much slenderer rays, on which the paxillar area is very narrow; constantly very small paxillae; much more numerous marginal plates; lower inferomarginals, of which the whole exposed surface is confined to lateral surface of ray; very delicate and not at all flattened fasciole spinelets; smaller and more numerous actinal plates in each corresponding double series; differently shaped and more angular adambulacral plates, with a different armature; madreporic plate with finer and more numerous ridges. R=52 mm., r=14 mm., R=3.7 r; breadth of ray at middle of R, about 10 mm. (An unusually slender rayed *crispatus* from Japan: R=2.8 r; breadth of ray at middle of R, 14 mm.)

---

[1] An exception in *Benthogenia*.

Description.—Rays constantly long and slender with wide, rounded interbrachia; disk moderate. Paxillar area narrow on rays, being about equal at the middle to height of combined marginal plates. Paxillae small, delicate, with upward of 10 slender equal terete spinelets on the largest, 4 or 5 on the smaller. A prominent slender cone present on center of disk, on which the plates are smaller than elsewhere.

Marginal plates numerous (26 or 27 to a ray in each series), the superomarginals proximally higher than inferomarginals, distally subequal. Fascioles deep between superomarginals, very shallow between inferomarginals, the spinelets supporting the membrane being delicate and slender, and relative to height of plate, longer than in *crispatus*. The superomarginals are lower in *orientalis* than in *crispatus*, the height being equal to about the length of one and a half plates in the interbrachium (two in *crispatus*), while far along ray both series are square (higher than wide in *crispatus*). The inferomarginals are conspicuously lower than in *crispatus*, the exposed surface being confined to lateral wall of ray, while in *crispatus* they encroach markedly upon the actinal area. About 8 to 10 fasciolar spinelets in total width of an interbrachial inferomarginal, about 12 to a superomarginal (respectively about 14, and 12 to 14 in *crispatus*). The specialized marginal spines slenderer than in *crispatus* and the inferomarginal series sometimes absent except on outer part of ray. The inferomarginal spines have a hyaline tip and are slenderer and shorter than the superomarginal. Each series occupies the same relative position on plate as in *crispatus*.

Actinal interradial areas smaller than in normal *crispatus*. The plates being smaller, usually more numerous, and the fasciolar spinelets more delicate. In either double series nearest the interradial line there are 16 to 23 plates (8 to 12 in a single series). In *crispatus*, 16 plates is usually the maximum number.

Adambulacral plates with the aboral half of the furrow margin excavated to receive the tube foot, the adoral half being prominent and angular with three tapering sharp spinules, the median the longest, proximally equaling width of plate, distally exceeding width.

One or two smaller spinelets continue the furrow series along the concave portion of margin, and directly behind these on the surface of plate is a conical hyaline spinelet, stouter and shorter than the furrow spinelets, except on the first five or six plates, as the subambulacral becomes smaller from the fifth plate toward the mouth, and is more delicate than the furrow series.

Mouth plates with 4 or 5 marginal, and 5 to 8 suboral, spinelets.

Superambulacral plates present, small, the first plate occurring on the fourth ambulacral ossicle (on the third in *crispatus*).

Type.—Cat. No. 30505, U.S.N.M.

Type-locality.—Station 5528, between Siquijor and Bohol Islands, Philippines, 429 fathoms, globigerina ooze, bottom temperature 53.3° F.

Distribution.—From the east coast of Luzon to Borneo and Celebes, 339 to 742 fathoms, on globigerina ooze and mud.

Specimens examined.—Thirty-three.

Specimens of Ctenodiscus orientalis examined.

Station.	Locality.	Depth.	Nature of bottom.	Bottom temperature.	Number.
		Fathoms.		° *F.*	
5126	Sulu Sea, vicinity southern Panay, 10° 34′ 45″ N.; 126° 47′ 30″ E.	742	Soft green mud	49.5	4
5274	China Sea, SW. of Manila Bay	525	Gray mud, sand	41.3	1
5423	Sulu Sea, vicinity Cagayanes Is., 9° 38′ 30″ N.; 121° 11′ E.	508	Gray mud, coral sand	49.8	2
5460	Lagonoy Gulf, E. coast Luzon, 13° 32′ 30″ N.; 123° 58′ 06″ E.	565	Gray mud		2
5470	Lagonoy Gulf, E. Coast Luzon, 13° 37′ 30″ N.; 123° 41′ 09″ E.	560	Mud		1
5499	Mindanao Sea, vicinity of Iligan Bay	554	Green mud, fine sand	52.3	2
5527	Between Siquijor and Bohol Islands	392	Globigerina ooze	53.3	7
5528	do	439	do	53.3	3
5529	do	441	Gray mud, globigerina		1
5585	Sibuko Bay, Borneo	417	Fine sand	41.1	1
5586	do	317	Gray mud		1
5587	Gulf of Boni, 3° 17′ 40″ S.; 120° 36′ 45″ E	415	Green mud, sand coral		2
5605	Gulf of Tomini, Celebes, 0° 21′ 23″ N.; 121° 31′ 10″ E.	647			1
5618	Molucca Passage, 0° 37′ N.; 127° 15′ E	417	Gray mud		1
5619	Molucca Passage, 0° 35′ N.; 127° 14′ 40″ E.	435	Fine gray sand, mud		1
5656	Gulf of Boni, 3° 17′ 40″ S.; 120° 36′ 45″ E.	484	Gray mud	41.2	3

Subfamily GONIOPECTININAE Fisher.

Goniopectininae FISHER, 1916*a*, p. 2.

Diagnosis.—Marginal cribriform organs consisting of discrete spinelets covered by a single webbed series on the transverse margin of the plate; well-developed intestinal coecum, intestine, and apical pore.

KEY TO THE KNOWN GENERA OF GONIOPECTININAE.

a^1. No odd interradial marginal plate; a fimbriate channel leading from outer end of mouth plates to the median interradial cribriform organ.
Goniopecten Perrier.

a^2. An odd interradial marginal in both series; a double column of actinal intermediate plates replacing the interradial fasciole, and meeting the odd marginal--*Prionaster* Verrill.

Genus GONIOPECTEN Perrier.

Goniopecten Perrier, 1881, p. 24. Type, *G. demonstrans* Perrier.

GONIOPECTEN ASIATICUS Fisher.

Plate 4, fig. 1; plate 5, fig. 2; plate 7, figs. 3, 3*a–c;* plate 8, figs. 1, 1*a*.

Goniopecten asiaticus Fisher, 1913*a*, p. 601.

Diagnosis.—Differing from *G. demonstrans* Perrier in having a complete series of spines on both supero- and inferomarginal plates, and open cribriform organs between the proximal marginals. R=135 mm., r=27 mm., R=5 r; breadth of ray at base, 31 mm. Disk moderate; rays long, stout, with vertical sides. Marginal plates massive, with fasciolar grooves containing cribriform organs, those proximally being open as in Porcellanasteridae. Paxillae large, crowded, with upward of 60 short, subequal spinelets on rather high tabula. Adambulacral plates with 6 to 10 furrow spines, the adoral conspicuously enlarged on the proximal plates; also with 1 or 2 prominent subambulacral spines distally, 5 to 8 proximally.

Description.—The abactinal paxillae are close-set, frequently in contact, flat-topped, and rather large. The largest are on the proximal radial areas, decreasing in size toward center of disk and along rays, and from the radial line toward margin of area. On outer fifth of ray the superomarginals are in contact medially. The paxillae are arranged in not at all regular, oblique, series extending from the narrow median radial area, where they are not in regular order, to marginal plates, about 7 of these ill-defined rows corresponding to 2 superomarginal plates at base of ray. The bases of the median radial paxillae are broadly elliptical; those of the dorsolateral areas are subcircular or poorly defined hexagons and pentagons. Neither sort are very regular, and the plates are separated usually by a slight interspace. The plates have a high shaft or tabulum, slightly narrowed at the summit and often variously compressed or with 3 to 5 unequal sides, rather than a circular cross-section. The spinelets are very much shorter than the tabulum and commonly stand upright, forming a compact elliptical, or three to five-sided group of 40 to 60 (on the larger paxillae). The spinelets are cylindrical, membrane-invested, and the tip is rounded or often knobbed with membrane, while the peripheral series has an inconspicuous web at the base. When the spinelets radiate apart the paxilla is roundish. Far along the ray there are 10 to 15 spinelets on the dorsolateral paxillae, and upward of 40 on the median radial.

Papulae absent from median radial line; elsewhere usually in sixes about each plate.

Superomarginal plates 42 to a ray, the last 10 or 11 on each side of a ray in contact medially, and not corresponding plate to plate, but sometimes alternating. Beyond the interbrachial arcs the plates encroach more and more upon the abactinal area as the extremity of ray is approached, so that from being proximally higher than wide they become wider than high. The general surface of the plate is covered with smooth skin and each bears on the rounded angle between the dorsal and lateral face a short, sharp, slightly compressed, conical spine. A similar spine occurs in a corresponding position on each inferomarginal. Proximally the vertical fasciolar grooves (continuous between both supero- and inferomarginal plates) are wider than the elevated ridge separating them, but become narrower toward the end of the ray. The margin of the elevated ridge is provided with a series of numerous delicate spinelets entirely immersed in a web, which continues uninterrupted to the adambulacral plates, roofing over the channels between the consecutive double series of actinal intermediate plates. The grooves between the marginal plates are closely packed with delicate spinelets in quincunx, these being visible at base of ray, and forming specialized cribriform organs wider than the naked ridge separating successive grooves. But these cribriform organs, along with the groove containing them, become narrower and narrower toward the end of ray, and beyond the midde of ray are entirely roofed over by the peripheral web. The cribriform organs are slightly wider at the top than at the lower end, and contain about 16 vertical rows of unwebbed spinelets. On the inferomarginal series, the organ, which is absolutely the same and continuous with that of the superomarginal, narrows quickly and ends at the ventrolateral angle of the ray. Proceeding along the ray the organs become closed over by the peripheral roofing web somewhat sooner than do the superomarginal fascioles. The exposed surface of the cribriform organs forms a shallow V-shaped channel paved by the tips of the spinelets.

The lateral face of the inferomarginal (between the ventrolateral spine and dorsal suture) is proximally about two-thirds as high as that of the corresponding superomarginal, but beyond basal third of ray becomes nearly or quite equal. There is a slight depression marking the suture between the two series of marginals, but no fasciole, the membrane being continuous. The actinal surface of inferomarginals is proximally slightly wider than high and subequal distally. The cribriform organs end abruptly at the ventrolateral angle, the channels between that point and the furrow being shallow, and covered by the webbed spinelets only. Terminal plate broadly obovoid, depressed, with sometimes a spine on ventrolateral corner.

The actinal intermediate plates extend to the eighteenth inferomarginal, or somewhat less than half the length of ray, but beyond the fifth inferomarginal there is only a single series, largely obscured by membrane. The first double row of plates extends from the first inferomarginal to a mouth plate, and touches also the first 2.5 or 3 adambulacrals; these two series contain 7 and 6 plates, respectively. The second double series, with 5 and 4 plates, corresponds to part of the third, the fourth, and half the fifth adambulacrals, or to the third and fourth only. The third double series has 3 plates in each row, and the fourth and fifth double series have 2 plates in each row. In addition to the flattened, rather broad, delicate spinelets supporting the marginal web, some of the plates have 1 or 2 inconspicuous spinelets largely obscured by membrane.

The adambulacral plates have an angular furrow margin. The facet or side toward the mouth is shorter on the first 10 or 12 plates than the other facet. The first 4 or 5 plates appear as if the furrow margin were oblique, as the short adoral facet is wholly occupied by an enlarged furrow spine. The first plate is compressed. The furrow spines increase from 6 on the first plate to 9 or 10 far along the ray. Proximally, the adoral spine of the series is much enlarged, the others being graduated in length to the end of the series, the last being short. Beyond the sixth or seventh plate the enlarged spine decreases in relative size, and gradually moves toward the center of the group. The spines form a palmate radiate group, are stout, webbed basally, and have a little knob of tissue on the tip. The first 7 or 8 plates have 5 to 8 stubby spinelets on the margin, more or less involved in the web. These become smaller distally, except 1 or 2, which stand on the aboral margin, and become slightly larger and more pointed. The first 6 or 7 plates have a fasciolar groove adjacent to actinal intermediate plates, but beyond this point the membrane is continuous.

Mouth plates prominent, the combined pair being narrowly truncate-elliptical. That part of the margin bordering on the furrow has 6 or 7 slender spines, followed on the inner end of plates by 2 heavier, longer, blunt spines (shorter than enlarged adambulacral spine). These are placed higher (or nearer the median suture) and merge into a series of 7 or 8 similar spines along the median suture. Six or 7 other spines of about the same length, but slenderer, form an angular series on surface of plate above the small furrow series, and thence along the border of suture adjacent to first adambulacral.

Madreporic body convex, with five striae, situated 1.5 times its own diameter from marginal plates. It is as wide as the length of first 2 superomarginals. Ampullae single.

Type.—Cat. No. 30506, U.S.N.M.

Type-locality.—Station 5121, east coast of Mindoro (lat. 13° 27′ 20″ N.; long. 121° 17′ 45″ E.), 108 fathoms, dark green mud; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This species differs from *G. demonstrans* Perrier in having, proximally, more open cribriform organs, in having a row of spinelets on both series of marginal plates, larger paxillae, superomarginals in contact distally, and a different adambulacral armature.

Genus PRIONASTER Verrill.

Prionaster Verrill, 1899, p. 215.

KEY TO THE KNOWN SPECIES OF PRIONASTER.

*a*¹. A specialized or enlarged spine on the distal transverse border of the adambulacral plates beyond proximal third of ray; inferomarginal spines, well developed and present on all the plates; interbrachial cribriform organs more or less open.

  *b*¹. Superomarginal spine conspicuous and present on all the plates; paxillae small.

    *c*¹. R=not more than 5 r; distal superomarginals apparently in contact medially; madreporic body small with transverse striae; cribriform organs only slightly open, in interbrachium; odd interradial double series of actinal intermediate plates narrow at inner end, the series not wedge-shaped; first adambulacral perceptibly compressed; 10 or 11 furrow spinelets________________________________*analogus*, p. 50.

    *c*². R=more than 6 r; distal superomarginals not in contact medially; madreporic body large with radiating striae; cribriform organs open; odd interradial double series of actinal intermediate plates wide at inner end, the combined series wedge-shaped; first adambulacral not compressed; 12 or 13 furrow spinelets________________*gracilis*, p. 55.

  *b*². Supermarginal spine absent or very small, and present on only a part of the plates; paxillae very large; madreporic body large with radiating striae; cribriform organs moderately open; paxillar area reaching terminal plate____*megaloplax*, p. 56.

*a*². No enlarged spine on distal transverse border of adambulacral plates; inferomarginal spines small and sometimes absent from first few plates; interbrachial fascioles closed, the combs meeting in the middle of the faciole; paxillae at base of ray with 7 or 8 central and 15 to 17 peripheral spinelets; 12 furrow spines; actinal surface of inferomarginals minutely bossed under the skin____*elegans*.

PRIONASTER ANALOGUS Fisher.

Plate 3, fig. 1; plate 4, fig. 2; plate 6, fig. 2; plate 8, fig. 3, 3*a*–*c*.

Prionaster analogus Fisher, 1913*a* p. 602.

Diagnosis.—Superficially resembling *Goniopecten asiaticus*, but with smaller paxillae. Differing from *P. elegans* Verrill in having smaller and less compactly placed paxillae, an enlarged spine on the distal transverse border of plate, slightly open cribriform organs in interbrachium, and no minute bosses on the actinal surface of the inferomarginal plates. Rays 5. $R = 105$ mm., $r = 23$ mm., $r = 4.6\ r$; breadth of ray at base, 24 mm.; at eighth inferomarginal, 12 mm. Rays long, slender, tapering abruptly at base, then scarcely at all until near the end; rays roughly rectangular in section (about half as wide as high), the four angles abruptly rounded; disk moderate; interbrachial arcs wide and open. Paxillae rather small; madreporic body medium sized; furrow spines, 10 or 11, and beyond base of ray, a subambulacral spine which is slightly larger than inferomarginal spine.

Description.—Paxillar area narrow on outer two-thirds of ray, and almost obliterated for the length of the distal 10 or 11 superomarginals, which very nearly touch medially. Paxillae small, rather close-set, arranged in slightly oblique transverse rows on either side of the radial line, where the plates are not more crowded. Sometimes the rows can be traced completely across the ray. About 9 of them correspond to 2 superomarginals at the base of ray. The abactinal plates are broadly elliptical to subcircular or faintly hexagonal, and are not in contact. Those in the interradii are largest. The tabulum or stalk of the paxilla is relatively high, has much the same shape in section as the base (although often more compressed or with several sides) and is crowned by a group of short, terete, knobbed spinelets of which 6 to 9 ordinarily form the radiating basally webbed peripheral series and 1 to 3 or none occupy center of group. Relatively few large paxillae have 20 peripheral and 8 to 10 central spinelets. Papulae in sixes about each plate; absent from midradial line, and a stellate area on center of disk.

Marginal plates exactly correspond. Superomarginals (40 to a ray) are higher than inferomarginals except on outer part of ray where they are subequal, and where the former are wider than high. The last 15 or 16 marginals (of both series) have a few low granuliform prominences on the dorsal and ventral surfaces, these encroaching upon lateral surface also near the end of ray. Each plate of both series bears on the lateral rounded angle and aboral edge a stout, short, sharp, conical spine, sometimes somewhat curved and with a clear tip. The spinelets supporting marginal web are delicate, close together, and in the interbrachial arc are longer than the bare exposed ridge of the plate. Those of inferomarginals are not different from the superomarginal spinelets. The webs nearly meet across the cribriform organs, the spinelets of which can be seen between the edges of the webs. Farther along the ray the webs entirely cover the spinelets beneath. In the interbrachium the ridge between the cribriform organs is narrower than the cribriform organs themselves, and also narrower than the depth of the V-shaped groove containing the organ. The cribriform organs extend from the upper end of plate to actinolateral spine, and thence as simple channels covered only by the webs, to the ambulacral furrow. The spinelets supporting the webs on actinal surface are much coarser than those of lateral surface. Supporting the web along one side of an interradial superomarginal are about 30 spinelets, and of the corresponding inferomarginal as far as the spine, about 15. The odd interradial plates are just like the others. Terminal plate triangular as seen from above, with five short spines on the broad distal end. In a young specimen these are relatively much longer and protect the terminal tentacle.

Actinal intermediate plates extend to thirteenth inferomarginal; but beyond the fifth there is only a single longitudinal series. Each double transverse series corresponds accurately to an inferomarginal, that opposite the odd plate meeting the mouth plate and first or first and second adambulacrals. There are eight plates in each row of the odd interradial duplicate series. Surface of plates smooth, covered by thin membrane. There are ordinarily 5 to 7 spinelets on the margin of each plate that borders a fimbriated channel. From the inner or coelomic side the plates are seen to be strongly imbricated, the free edge being that toward margin.

Adambulacral plates with an angular furrow margin, the apex of which is nearly in the center of plate beyond middle of R, but moves toward the adoral edge of plate as the mouth is approached, until on the first 5 or 6 plates the apex is so near the adoral side of plate that the free margin is quite oblique, as in *Goniopecten.* The furrow margin bears, on the first (compressed) plate 6 to 8 spines, on the rest 10 or 11, basally webbed; they are rather long, close-set, blunt, or dully pointed, and the longest spine is on the apex of the angle, the rest becoming gradually and markedly shorter toward either end of series. The groups tend to meet across the furrow and segregate consecutive pairs of tube feet. At the base of ray, about 10 plates are free from the actinal plates and bear a marginal series of 6 to 8 stout spinelets webbed for about half their length. One or 2 of these on the aboral edge of plate become gradually enlarged. Beyond the tenth plate one outstrips the other, forms a specialized sharp subambulacral spine, similar to but slightly larger than the nearest inferomarginal spine. Far along ray the furrow spines decrease rapidly in size, while the subambulacral spine decreases slowly, so that there the discrepancy in size between the two is greatest, the subambulacral being the longer; proximally the reverse is true.

Mouth plates prominent actinally and very similar to those of *Goniopecten.* The plates are interradially long and narrow. The furrow series consists of 8 or 9 small spines, similar to but shorter than those of the first adambulacral, there being a slight angle in the series near inner end of plate. Two or 3 irregular series of much heavier, short, pointed spines occupy the sloping surface of each plate, increasing in size toward the inner end of plate, where one forms with its companion a pair of sharp conical teeth, which, however, do not belong to the true marginal series. The surface of each plate has 15 or 16 spines.

Madreporic body one and a third its own diameter from marginal plates. In diameter it equals the cross diameter of the combined mouth plates, or not quite the length of the first two superomarginals. It is crossed by striae radiating from an interradial point on the adcentral margin.

Anatomical notes.—As the internal organs of this genus have not been described, a few notes on their salient characters will be given. The stomach is large and simple, filling nearly the whole disk, and consists of a single spacious cavity without dorsal and ventral divisions. The general contour is roundish, but is subdivided into 5 broad shallow radial lobes, from each of which proceed directly 2 short olive-green hepatic coeca, scarcely equaling in length the minor radius. The 10 hepatic coeca are about equidistantly spaced on the periphery of stomach. On each side of the ambulacral ridge 2 strong muscular and tendinous bands, one arising from the first and second, and the other from the third ambulacral ossicle pass upward and spread out on the stomach, on each side of the base of a hepatic coecum. On the middle of the dorsal surface of stomach and connected with it by a small aperture is a small three-lobed intestinal coecum, from the dorsal side of which a very short intestine leads upward and opens by an almost microscopic pore. If this aperture is functional it must be simply an exit for products of the intestinal coecum.

Interbrachial septa wholly membranous. Gonads opening near marginal plates about 5 mm. on either side of septum. There are altogether 10 bunches, and they do not extend along ray. Polian vesicle in each interradius except that of madreporic canal, where there are 2. Ampullae single; tube feet pointed. First ambulacral plate enlarged and considerably thicker than those following, and the lower end is Y-shaped instead of spatulate. The proximal limb of the Y is much shorter than the other, and between the two is the first ampulla. The odontophore has two lobes toward the mouth and a single very much broader lobe between the lower ends of two neighboring ambulacral ossicles. The whole surface is entirely free. Superambulacral ossicles present but small at the proximal end of the series.

Type.—Cat. No. 30507, U.S.N.M.

Type-locality.—Station 5123, east coast of Mindoro, 220 to 283 fathoms, green mud.

Distribution.—Sulu Sea and Mindanao Sea, Philippine Islands, 219 to 283 fathoms.

Specimens examined.—In addition to the type, 4 from the following stations:

Station 5537, between Negros and Siquijor, 254 fathoms, green mud, bottom temperature 53.5° F.; 1 specimen.

Station 5541, off Point Tagolo, northern Mindanao, 219 fathoms, fine sand, broken shells, bottom temperature 53.3° F.; 1 specimen.

Station 5565, between Jolo and Tawi Tawi (east of northern Borneo) 243 fathoms, fine sand, shells; 2 specimens.

Remarks.—This species resembles more closely the Atlantic form, *P. elegans* Verrill than it does either *gracilis* or *megaloplax*. I have been able to compare the type with a specimen of *elegans* from station 2400, Gulf of Mexico, 169 fathoms. The differences are contrasted below:

analogus.	*elegans.*
Paxillae at base of ray with 1 central and 9 or 10 peripheral spinelets; paxillae not close-set on disk; smaller.	Paxillae at base of ray with 7 or 8 central and 15 to 17 peripheral spinelets; paxillae close-set on disk and larger.
Intervening ridge between marginal fascioles about half as broad as the fasciole, or even less than half (in interbrachium).	The intervening ridge as wide as the fasciole.
Fasciole between inferomarginals not narrowing toward the actinolateral angle of ray (as marked by the lateral spine). Inferomarginal fascioles on lateral face of interbrachium not narrower than the superomarginal fascioles.	Inferomarginal fascioles of lateral face of interbrachium narrowing toward the actinolateral angle of ray; the fascioles are narrower than the corresponding superomarginal fascioles.
In interbrachium the fascioles or cribriform organs are slightly open, and are deeper, with more numerous spinelets.	The fascioles or cribriform organs of interbrachium are closed, the combs meeting in the middle of the fascioles.
Inferomarginal spines larger.	Inferomarginal spines smaller and sometimes absent from first 2 or 3 plates.
Actinal surface of inferomarginals narrower, without granulations; interradial inferomarginal plate bordered by about 6 or 7 spinelets, between the large actinolateral spine and the inner margin of plate.	Actinal surface of inferomarginal plates with about 12 tiny granuliform protuberances or bosses under the skin; interradial inferomarginal plate bordered by 11 or 12 spinelets between the actinolateral spine (if this is present) and inner margin of plate.
Nine to 11 furrow spines, there being an enlarged spine on the distal transverse border of plate beyond the proximal third of the ray.	Twelve furrow spines, there being no enlarged spine on the distal transverse border of the plate.
First 10 adambulacral plates are separated from the actinal intermediate plates by a longitudinal fasciole.	Only the first 3 adambulacrals are so separated.

PRIONASTER GRACILIS Fisher.

Plate 3, fig. 2; plate 6, fig. 1; plate 9, fig. 1, 1*a*–*b*.

Prionaster gracilis FISHER, 1913*a*, p. 603.

Diagnosis.—Differs from *Prionaster analogus* in having conspicuously longer rays, with a distally wider paxillar area which reaches terminal plate; paxillae with slenderer, sharper spinelets; madreporic body larger, with different striation; superomarginals narrower abactinally; cribriform organs open and exposed proximally; longer marginal spines; more numerous adambulacral spinelets; first adambulacral not compressed; double series of interradial actinal plates wider at inner or central end; enlarged subambulacral on middle portion of ray only. R=165 mm., r=24 mm., R=6.9 r; breath of ray at base, 24 mm., at tenth inferomarginal, 14 mm.

Description.—Rays very long and slender throughout the whole length. Paxillae small and crowded, about the same size as in *analogus*, but the spinelets slenderer, tapering, and bluntly pointed, not capitate or clavate as in *analogus*. The paxillae decrease in size from the proximal radial region toward the end of ray and center of disk. About 9 paxillae correspond to the first 2 superomarginals. There are about 14 spinelets to a large paxilla. At middle of ray the paxillar area is 2.5 times the width of dorsal surface of superomarginals. The paxillae reach the terminal plate.

Abactinal plates lozenge-elliptical and more or less irregular on the ray, becoming more circular, with indications of 4 to 6 sides on the disk. On the rays the plates are slightly spaced, but just touch one another on the disk. The papulae extend nearly to tip of ray and are absent from a narrow radial strip, and from center of disk.

Superomarginals, 74, the distal plates about as wide as high (much wider than high in *analogus*), and the last 4 plates nearly touch the opposite ones medially. The paxillar area is wider distally than in *analogus*, and fewer marginals approach the median line despite the much longer ray. Cribriform organs much more open than in *analogus* and even more open than in *Goniopecten asiaticus*, especially between inferomarginals. In the interbrachium the width of the exposed portion of organ (exclusive of marginal web) is about 1.5 mm., or a little over one-third height of superomarginal, or one-half lateral face of the inferomarginal. The organs become narrower very gradually toward the end of ray. The marginal spines are as in *analogus* but are longer. Terminal plate with apparently but 4 terminal spines (only 1 ray perfect).

The interradial double row of actinal intermediate plates (7 in each series) is much broader at the inner end, therefore more wedge-shaped, than in *analogus*, owing to the fact that the first adambulacral plate is not compressed. The interradial area proper extends only as far as the fifth inferomarginal, but a single series of small plates (which are rudimentary distally) reaches the fourteenth inferomarginal.

Furrow margin of the adambulacral plates is angular as in *analogus* (but in the midregion of the ray not so strongly so), and there are 12 to 14 furrow spinelets, webbed for nearly half their length, the median spinelets being slightly the longest. Four or 5 shorter spinelets stand on the outer border of plate, immersed in membrane, one of them becoming a specialized subambulacral spine on the midregion of ray (but not enlarged on the distal or proximal part of the ray).

The transverse margins also bear 1 to 4 immersed spinelets. With the exception of the first and second, or first and third plates, the outer edge of the proximal adambulacrals not separated by a furrow from the actinal intermediate plates as in *analogus*, but the membrane is continuous. The first plate is scarcely compressed.

Mouth plates very prominent actinally. The marginal series of 12 spinelets is angular, giving the inner end of the combined pair a truncate appearance; but the series does not dip down into furrow quite so conspicuously as in *analogus*, although somewhat. The inner spine is enlarged into a conical tooth and just above it one or two suboral spines are similarly enlarged. Numerous smaller spines are scattered over the surface of plates.

Madreporic body situated its own diameter from marginal plates, its width equaling the length of three interbrachial superomarginals (one and a half in *analogus*). Striae fine, radiating from an eccentric point (nearer the adcentral margin than outer edge). In *analogus* they radiate from an interradial point on the adcentral margin.

Type.—Cat. No. 30508, U.S.N.M.

Type-locality.—Station 5425, Sulu Sea (lat. 9° 37′ 45″ N.; long. 121° 11′ E.), 495 fathoms, gray mud, coral sand, bottom temperature 49.40° F.

Distribution.—Sulu Sea and off Southern Luzon, Philippine Islands, 338 to 495 fathoms.

Specimens examined.—In addition to type, 1 from station 5373, off Marinduque Island (south of Luzon), 338 fathoms, soft mud, bottom temperature 51.8° F.

PRIONASTER MEGALOPLAX Fisher.

Plate 4, fig. 3; plate 5, fig. 1; plate 9, fig. 2, 2*a-b*.

Prionaster megaloplax Fisher 1913*a*, p. 603.

Diagnosis.—Differing from *Prionaster analogus* in the following features: Large compact paxillae with very numerous spinelets; large madreporic body; superomarginals not in contact distally; superomarginal spines absent or rudimentary; more open cribriform organs; relatively larger inferomarginal spines; the odd interradial double series of actinal intermediate plates broader at inner end and with more plates; first adambulacral not markedly compressed; more numerous (12–13) furrow spines. R=250 mm., r=50 mm. R=5 r; breadth of ray at base, 56 mm.; at tenth superomarginal, 28 mm.; at middle of ray, 20 mm.

Description.—General form robust; disk large, rays long, comparatively slender, but relatively shorter than in *gracilis*, and broader at the base. Paxillae conspicuously larger than in *analogus* and *gracilis*, and, like those of *Goniopecten asiaticus*, closely crowded, and as in other species arranged in oblique transverse rows on either side of the midradial strip of irregular ones. Pedicel of paxilla stout, often compressed, bearing a flat-topped polygonal group of equal, terete, blunt spinelets, about 25 to 30 occupying the periphery, and 20 to 40 the center. Far along ray there are about 2 to 5 central and 10 to 15 peripheral spinelets, blunter or more capitate than those on large paxillae. The paxillar area tapers evenly to the terminal plate, none of the superomarginals being in contact medially.

The abactinal plates were examined from the inner side on the ray only. Here the plates are independent, kite-shaped (6-sided, with the transverse diameter the shorter) and arranged in regular oblique rows on either side of the midradial band where the plates are irregularly elliptical, somewhat irregular in arrangement, and larger than the lateral plates. Papulae in sixes. There is a distinct though small anal aperture.

Marginal plates with rather open cribriform organs in interbrachium. The width of the exposed area of fasciolar spinelets is equal to one-fifth, or slightly less, the height of superomarginal. Beyond middle of ray the fascioles are roofed over by the marginal web, unless the latter is unduly shrunken by alcohol. Superomarginal plates, 74 in number, confined to side of body in interbrachium. Far along ray they gradually encroach upon the abactinal area until near extremity the width equals or slightly exceeds the height. The special superomarginal spinule is either absent, or present as a small spinelet on the proximal half of the ray. Inferomarginal spine larger than in *analogus* and about as in *gracilis*. In the interbrachium it equals or exceeds half the height of a superomarginal plate. One or 2 proximal plates have 2 spines.

Actinal interradial areas similar to those of *gracilis*, the interradial double series being broad at inner end, and containing, each, 10 plates. Besides the fasciolar spinelets there are here and there a very few superficial spinelets under the membrane. The intermediate plates extend to tenth inferomarginal.

Adambulacral plates strongly angular, the adoral facet the shorter. Furrow spines 12 or 13, terete, capitate, in a palmate series and basally webbed. The spines near apex of angle are the longest (about equal to length of plate) thence decreasing in length toward either end of series. A pointed, specialized subambulacral spine, situated on the outer aboral corner of plate, is present, accompanied sometimes by a shorter companion, while 3 or 4 other shorter spines occur on the margin of plate, all immersed in membrane. The first dozen plates have the marginal spines subequal, or one slightly enlarged, and all more or less completely involved in membrane. Here and there a plate is partly separated from the actinals by a groove; usually the skin is continuous between actinals and adambulacrals. First adambulacral not markedly compressed.

Mouth plates large, the combined pair truncate at inner end. Marginal series of spinelets, 13, strongly angular, the spinelet at apex being deep in furrow, and the rest unequal; inner one or two enlarged into teeth. About half the spinelets face on actinostome and the rest on the furrow. Furrow surface of plate excavated for first tube foot. Surface of plate with 20 to 30 spinelets, about 10 of which border median suture and the rest stand below these in a couple of very irregular and variable series.

Madreporic body very large, in diameter equal to the length of the first 3 superomarginals, and situated twice its diameter from margin. Striae fine, radiating from a point midway between center and adcentral (inner) margin.

Type.—Cat. No. 30509, U.S.N.M.

Type-locality.—Station 5624, between Gillolo and Makyan Islands, Molucca Islands (lat. 0° 12′ 15″ N.; long, 127° 20′ 30″ E.), 288 fathoms, fine sand, mud.

Distribution.—Molucca Islands, 230 to 288 fathoms.

Specimens examined.—In addition to the type, an abnormal example from station 5625, between Gillolo and Kayoa Islands, Molucca Islands (lat. 0° 07′ N.; long. 127° 28′ E.), 230 fathoms, gray mud, fine sand.

Remarks.—The following differences separate this species from the two preceding: The paxillae are much larger, with many more spinelets; the superomarginal spinule is inconspicuous and present only on the middle portion of ray. *Megaloplax* is separated from *analogus* by several additional characters: The large madreporic body; superomarginals not touching along the radial line, distally; more open cribriform organs; first adambulacral not markedly compressed; odd interradial double series of actinal intermediate plates conspicuously broader at inner end (more than 3 times width of outer end); furrow spinelets 12 to 13 (10 or 11 in *analogus*). The following additional differences separate *megaloplax* from *gracilis:* Ray shorter in *megaloplax* (R=5 r); dorsolateral edge of ray more rounded; ray broader, with a decidedly broader paxillar area, which tapers more evenly from the base toward tip, and despite their larger size, there are more paxillae in a transverse row across ray than in *gracilis* (at middle of ray, 28 in *megaloplax*, 17 in *gracilis*); subambulacral spine more conspicuous in *megaloplax.*

The example from station 5625 is remarkable from having only two interradii normal as regards the odd marginal plates and the odd double series of actinals leading therefrom to the mouth plates. These two interradii are that of the madreporic body and the adjacent one to right (between bivium and trivium). One other interradius has paired inferomarginals and superomarginals, and paired double series of actinal intermediate plates. Another has an odd superomarginal and paired inferomarginals and actinals. The fifth has paired superomarginals and apparently paired inferomarginals, but the odd plate is pushed to one side of the median interradial line and a supernumerary plate is inserted in the ventral series a few plates distant. The odd actinal double series is also crowded to one side, but its inner end meets the combined mouth plates. The disk is somewhat smaller than that of type, and the paxillae of disk a trifle smaller.

This abnormal specimen does not particularly suggest a hybrid, with *Goniopecten asiaticus.* It is puzzling to account for the unstability of the generic characters, however. In one interradius the specimen is *Goniopecten*, in two it is *Prionaster*, while in two others it is a combination or mosaic of the two genera.

Family ASTROPECTINIDAE Gray 1840, emended.

Subfamily CRASPIDASTERINAE Fisher.

Craspidasterinae FISHER, 1916*a*, p. 3.

Diagnosis.—Resembling the Goniopectinidae in having a single series of webbed peripheral spinelets on the marginal and actinal plates, but differing in lacking the characteristic double serial arrangement of the actinal intermediate plates, which are arranged essentially as in the Astropectininae; in having patently double ampullae, and in the form of the hepatic coeca which arise from five radial diverticula of the dorsal part of the stomach, as in Astropecten.

Genus CRASPIDASTER Sladen.

Craspidaster Sladen, 1889, p. 175. Type, *Archaster hesperus* Müller and Troschel.

CRASPIDASTER HESPERUS (Müller and Troschel).

Plate 9, fig. 3.

Archaster hesperus Müller and Troschel, 1840, p. 104; 1842, p. 65.
Stellaster sulcatus Möbius, 1859, p. 11, pl. 5, figs. 1 and 2.
Craspidaster hesperus Sladen, 1889, p. 177, pl. 17, figs. 5–7; pl. 18, figs. 1–4.
Astropecten macer Sluiter, 1889, p. 297; 1895, p. 53.

Sladen has given figures and a careful description of this species and has noted the principal variations.

The largest of the Philippine specimens has R=52 mm., r=12 mm., R=4.33 r; superomarginal plates 38; furrow spines, 6–7. In this specimen the little thumblike subambulacral spinelet described and figured by Sladen in his Hongkong specimen is not present, and the fringe of spinelets along the inner edge of the inferomarginal plates is found much farther along ray than indicated by Sladen. It is variable even in the Philippine examples; in some it persists nearly to the end of the ray (station 5209) while in an example from station 5375 the fringe is rudimentary beyond the limit of actinal intermediate plates.

Anatomical notes.—The midradial line and center of disk are without papulae. Here the plates are nearly circular or with 5 or 6 faint scallops by which the plates overlap slightly. Elsewhere the plates have 5 or 6 short lobes by which they are in connection with neighboring plates. This arrangement is unlike that of *Prionaster* and *Goniopecten*, in which the plates are independent. The papulae are usually in sixes about each plate. In the family Astropectinidae all gradations between independent circular or elliptical plates and stellate imbricated ones are found.

The stomach is spacious and from the dorsal part arise five radial diverticula, each of which, dividing, gives rise to two hepatic coeca which extend along ray to about the seventh superomarginal. Thus the coeca arise from a common tube, and not independently as in *Prionaster*. The ventral portion of the stomach, which is very extensible, is not separated from the aboral portion by any sharp line of division. Its radial portions contain small gastropods and pelecypods. The intestinal coecum is represented by a single large saclike diverticulum lying in an interradius on the dorsal surface of stomach, its extremity nearly reaching the marginal plates. I can not determine whether this connects with the stomach, but a minute intestine passes upward in the interior of a slight epiproctal cone. A lumen is present, and presumably the intestine opens by a tiny pore, although I have not been able to see it. The paxillae are very small and crowded in this region. Viewed from the coelomic side, the intestine appears to pierce the integument.

Interbrachial septa membranous. Gonads in a single tuft attached to dorsal integument on either side of septum and near marginal plates. Ampullae double; tube feet pointed, without deposits in the walls.

A Polian vesicle in each interradius except that of madreporic canal where there are two. Well developed, slender, superambulacral ossicles are present.

The internal anatomy as a whole is rather more like *Astropecten* than *Prionaster*, especially in regard to the stomach. In certain features, as in the ambulacral system, both resemble *Astropecten*.

Type-locality.—Japan (Müller and Troschel).

Distribution.—Japan to western shore of Bay of Bengal (Vizagapatam, India [Koehler]; Mergui Archipelago [Rudmose Brown]; Singapore [von Martens]; Banka Straits [Sladen]; Philippines [Sladen]) and south to the Aru Islands, west of New Guinea (Koehler). The southernmost locality in the Philippines is station 5235, Pacific Ocean, off Mindanao. The bathymetrical range is 9 to 107 fathoms.

Specimens examined.—Sixteen specimens from the following Philippine localities:

Specimens of Craspidaster hesperus examined.

Station.	Locality.	Depth. *Fathoms.*	Nature of bottom.	Number.
5207	Off Western Samar	35	Green mud, sand.	5
5208	....do	26	Soft green mud.	2
5209	....do	20	....do	2
5235	Off east coast Mindanao	44	Soft mud	1
5358	Sulu Sea, off Sandakan Harbor, Borneo	39	Mud	4
5375	Off Marmaduque Island	107	Green mud	1
5131	East of northern Palawan	51	Sand	1

Subfamily ASTROPECTININAE Sladen.

Diagnosis.—Phanerozonia with large marginal plates, true paxillae, and parapaxillae; with pointed tube feet (a flat or true sucking disk being always absent); with double ampullae; no cribriform organs, but frequently well-developed marginal fascioles, which are never webbed; actinal fascioles never webbed; with an intestine, and usually an intestinal coecum; anus absent, small, or well developed; superambulacral plates always present.

This division corresponds exactly to the Astropectinidae as defined by me in Asteroidea of the North Pacific (1911*d*, p. 37). The family has been changed only by the addition of *Craspidaster*, for which a new subfamily has been made. The Astropectininae lack the webbed marginal and actinal fascioles of *Craspidaster.* While the name was coined by Sladen, the subfamily as here used is more extensive than his, as it includes several of his Archasteridae as well as subsequently described groups. For a discussion of this family see Fisher, 1911*d*, p. 37.

Genus ASTROPECTEN Gray.

Astropecten Gray, 1840, p. 180.

KEY TO THE SPECIES OF ASTROPECTEN HEREIN DESCRIBED.

a^1. Superomarginal spines in a single definite series continuous throughout ray, with exception sometimes of second, third, and fourth plates.

b^1. Superomarginal spines upright and prominent, proximally equaling or exceeding height of plate; no conspicuously enlarged subambulacral spine.

c^1. The second, or second and third, superomarginals without spines; inferomarginals with 4 or 3 large bristling spines in a transverse series; superomarginal spines 1.5 to 2.5 times height of plate. *polyacanthus*, p. 63.

c^2. Superomarginal spines continuous throughout ray; inferomarginal plates with 3 lateral spines and spaced therefrom, 1 on the actinal surface. *phragmorus*, p. 65.

b^2. Superomarginal spines small, much less than height of their plate; one of the subambulacral spines conspicuously enlarged.

c^1. Superomarginal spines all on inner edge of plates; 1 lateral spine with a small companion---- *mindanensis*, p. 67.

c^2. Superomarginal spines of first few plates at inner edge, thence moving to angle between lateral and dorsal surfaces of plate; some plates with occasionally 2 spines; lateral spines 2 or 3, with proximally 1 or more smaller actinal companions---- *inaequalis*, p. 69.

a^2. Superomarginal spines small, confined to first, or first 2 or 3 plates, or extending over half the length of ray, but not the entire length.

b^1. Rays short and stout; R less than 5 r; superomarginal spines on first, or first 2 or 3 plates only---- *velitaris*, p. 70.

b^2. Rays long and slender; R more than 6 r; superomarginal spines on a few proximal plates or on all but the last third of ray.

c^1. Subambulacral spines 3 or 4, none enlarged; superomarginal spine at base of ray only; mouth spines in regular series---- *luzonicus*, p. 82.

c^2. Superomarginal spines on all except outer third of ray; subambulacral spines more that 5, one in the first series enlarged; mouth spines irregularly arranged.

d^1. No superomarginal or inferomarginal pedicellariae; abactinal and adambulacral pedicellariae very few; paxillae medium-sized; superomarginals of proximal half of ray not longer than wide; lateral spines 3, sometimes 4---- *tenellus*, p. 84.

d^2. Numerous abactinal, superomarginal, inferomarginal, and adambulacral pedicellariae; superomarginals of the proximal (as well as distal) half of ray longer than wide, except the first 8 or 9 plates; lateral spines 4, 3 on distal third of ray---- *pedicellaris*, p. 87.

b^3. See also *monacanthus* and *eucnemis*, where a small spine may occur aberrantly on the first, or first 2 or 3 plates.

a^2. No superomarginal spines.
  b^1. Paxillae small, delicate; abactinal spiniform pedicellariae; furrow spines 4 or 5; deep water ---------- *cremicus*, p. 79.
  b^2. Paxillae medium or large; no abactinal paxillae; furrow spines 3.
    c^1. Rays long and narrow in the adult; R more than 5 r; lateral spines 2. *eucnemis*, p. 75.
    c^2. Rays stout and short, or of medium length; R less than 5 r; lateral spines 1 to 3.
      d^1. Lateral spines 2 or 3, with sometimes actinal accessory spinules; inferomarginal spinelets not remarkably flat and spatulate; superomarginal plates broad, with small granules ---------- *granulatus*, p. 73.
      d^2. Lateral spine, one; inferomarginal spinelets flat and scalelike; subambulacral spines very flat and broadly spatulate; superomarginal plates narrower, with large granules ---------- *monacanthus*, p. 74.

ASTROPECTEN POLYACANTHUS Müller and Troschel.

Astropecten polyacanthus MÜLLER and TROSCHEL, 1842, p. 69, pl. 5, fig. 3.

Notes on Philippine specimens.—In order to record the more evident variations in the armature of the 6 specimens I have drawn up a sort of synopsis or key.

a^1. Only the second superomarginal without a spine; superomarginal spines about 1.25 times height of their plate; superomarginal series of spines proximally 5, then 4, and only at tip of some of the rays, 3; they are slender, appressed and very sharp ---------- Catbalogan, Samar (1).
a^2. The second and third, rarely the fourth, superomarginal without a spine; superomarginal spines proximally 2 to 2.5 times height of their plate.
  b^1. Inferomarginal spines 4, narrow, slightly flattened, bristling. All actinal spinelets relatively longer and stouter than in b^2 and a^1; superomarginal and lateral spines unusually stout, the former the more robust. Station 5165 (1).
  b^2. Inferomarginal spines 3, the third situated at or near inner end of plate, spaced from the other 2.
    c^1. Superomarginal spines stout and long, proximally 2 to 2.5 times height of their plate; superomarginal plates higher than long on proximal half of ray; inferomarginal spines narrow, slightly flattened, sharp; paxillar area wider (opposite fourth plate equal to length of 3.5 to 4 succeeding superomarginals) ---------- Station 5165 (1); Usada Island (1).
    c^2. Superomarginal spines slenderer, and variable in length proximally; superomarginal plates (except the first 2 or 3) longer than high; outer inferomarginal spine conspicuously longer than the rest, flat, broader toward tip than at base, narrowing abruptly to a sharp point (rarely bifid); paxillar area narrow (opposite fourth superomarginal equal to length of 1.5 to 2.5 succeeding plates); the smaller inferomarginal spines are rather more delicate than in the preceding variety. This variety seems to be similar to a specimen mentioned by Sladen (1889, p. 201) from the Admiralty Islands ---------- Stations 5159 (1) and 5174 (1).

In the last variety the flattened leaflike, sharp lateral spines and narrow paxillar area produce a combination of characters which alters the general facies very markedly. When a sufficient number of specimens from many localities are examined by one person this species will be split up. Long ago Sladen[1] pointed out the possible error in too comprehensive species, such as *polyacanthus*. He said:

> Without calling in question the accuracy of M. Perrier's determination, the occurrence of such instances as this of a form presenting strongly marked variations at different stations within the area of its distribution, urges upon naturalists the necessity of exercising extreme caution against being led away by a tendency to group too comprehensively the forms which may be included within a large and widely distributed genus; for, however seriously the multiplication of frivolous "species" may embarrass a classification, the wholesale grouping, or, in other words, the unbounded extension of the limits of specific character, is productive of more injurious results, in that it curtails the precision of definition, and, whilst ignoring environment as a factor, divests nomenclature of one of its highest and most important qualities.
>
> From the fact that forms are separated by much smaller and less striking differences in an extensive genus, than in one of more limited scope, "species" in the larger group have often not such clearly marked or conspicuous characters as those which are presented by "varieties" in a less comprehensive genus. It follows that the judgment should be very cautiously exercised when tempted to embrace within a single species all the strongly marked distributional extremes of any widely spread type, however closely their connection may seem to be preserved through intermediate forms; for in many cases these gradations are nothing more or less than the links which indicate to us the development of "species," and are, in short, the stages with which generally we are unacquainted, owing either to the imperfection of knowledge, or more frequently by reason of their destruction through the hostility of unfavorable conditions.

Without a large series of specimens from numerous localities it will be difficult to arrive at a solution of *Astropecten polyacanthus*, for it is likely that the rather conspicuous individual and habitat variations somewhat mask small and constant differences due to wide geographic separation.

Type-locality.—Red Sea.

Distribution.—The Red Sea to Zanzibar and Mozambique, the Seychelles, Ceylon, Mergui, Andaman Islands, China, Japan, Philippines, Port Jackson, Australia, Admiralty Islands, Aru Islands, Fiji Islands, Hawaiian Islands.

Specimens examined.—Six specimens from the following localities:

Catbalogan, Samar, shore; 1 specimen.

Usada Island, vicinity of Jolo, shore; 1 specimen.

Station 5159, Tawi Tawi Group, Sulu Archipelago, 10 fathoms, coarse sand, shells; 1 specimen.

Station 5165. Same locality, 9 fathoms, coral; 2 specimens.

Station 5174. Vicinity of Jolo, 20 fathoms, coarse sand; 1 specimen.

---

[1] Journ. Linn. Soc. Zool., vol. 14, 1879, p. 429.

ASTROPECTEN PHRAGMORUS Fisher.

Plate 11, fig. 5; plate 14, figs. 1, 1*a–b*.

Astropecten acanthifer phragmorus FISHER, 1913*a*, p. 604.
Astropecten phragmorus DÖDERLEIN, 1917, p. 178.

Diagnosis.—Very similar to *A. acanthifer* Sladen, but differing in having narrower rays; more perpendicular superomarginals, bearing larger spines on the extreme upper and inner edge of plate (not spaced conspicuously therefrom); a relatively longer actinal inferomarginal spine and longer marginal spines generally (especially in proportion to width of ray); an incipiently enlarged subambulacral (more noticeable in young examples). R=48 mm., r=8 mm., R=6 r; breadth of ray at second superomarginal, 9 mm. The brownish marking seems to be distinctive also.

Description.—Rays slenderer than in *acanthifer* although the disk is no smaller. Sladen gives the proportions of the type as R=6.43 r, but the figure shows proportions of R=between 5 and 6 r, nearer 5. The narrower rays of the present species will be evident on a comparison of figures. Paxillar area very compact, the outlines of individual paxillae being sometimes difficult to distinguish. The paxillae are similar to those of *acanthifer*, but the spinelets are a little longer and slenderer, judging by the figure, although in the largest specimens, numerically about the same.

Superomarginal plates, about 35 in number, confined to side of ray proximally and forming a steep bevel; encroaching more and more upon the abactinal surface, and becoming relatively lower and more arched on outer half of ray. In *acanthifer* the proximal plates have a definite rounded angle between the dorsal and lateral surfaces, and on this angle the small, superomarginal spine is situated. In *phragmorus* the proximal plates slope very steeply, and nearly the whole of the upper end is occupied by the base of the stout, tapering, slightly flattened sharp spine, which, on the outer third of the ray, withdraws slightly from the inner edge of the plate. The superomarginal spines of *phragmorus* are situated as the two to four interbrachial spines of *acanthifer*. The first spine is 3 mm. long, stouter and longer than the rest, and slightly exceeds the height of plate; and all along ray the spines preserve the same proportion to their plate, as the plates become lower. They are much stouter and longer than in *acanthifer*. General surface of plate covered with slightly spaced spinelets, terete and blunt except in the middle where they are a little stouter and more squamiform, increasing in size around the base of spine.

Lateral inferomarginal spines 3, slender, tapering, slightly flattened, and sharp, the upper the longest and stoutest, on the proximal plates about 3.5 plates in length (about 5 mm.); second spine nearly as long as first; third about half as long as second, but in very young specimens sometimes relatively longer. The fourth spine is placed as in *acanthifer*, but is flattened and longer, being a little over one-half to about two-thirds the length of the longest lateral spine. This spine extends one-half to three-fourths the length of ray. As many as 5 proximal plates may have 2 of these spines, in a cross series. General covering of plate essentially as in *acanthifer*, except that there are no accessory spinules in front of the 3 lateral spines as figured by Sladen.

Adambulacral armature: (1) Furrow spines, 3, relatively long, flattened, slender, round tipped or truncate, the middle the longer, slightly tapering, with edge to furrow; the lateral also slightly tapering with flat side to furrow. (2) Subambulacral spines, usually 6, similar in character to furrow spines, slightly tapering and round tipped or truncate, arranged in 2 series, or with 1 in center, surrounded by 5; in this case there are 2 spines back of the furrow series, forming an oblique longitudinal series and back of these, 4 in a diamond-shaped arrangement. The aboral member of the first series is slightly larger than its companion, and in small specimens very much larger; in these there are only 2 or 3 subambulacrals, with a minute companion or two.

Mouth plates very similar to those of *A. acanthifer*. Any slight differences seem to be covered by individual variation.

Actinal intermediate plates, 4 in each interradius, with the slender spinelets in two close groups, in some cases forming incipient pedicellariae, in others a paxilla.

Madreporic body small, partly concealed, its own diameter or less from margin; very convex, and with rather coarse transverse striae.

Color in alcohol: rays with 2 or 3 broad crossbars of brown on buffy ground; and in addition some specimens have a narrow line proceeding along each radius from near middle of disk to end of ray.

Young.—Some small specimens, ranging in size from R. 10 mm., to R. 18 mm., have been referred to this form. The rays are much shorter than in the adult, R equaling 3 to 3.5 r. The paxillae are smaller and less compact, with 1 central and 5 to 8 peripheral spinelets on the disk and only 4 or 5 altogether on the ray. The superomarginal plates are well developed as in the adult, the first spine being the most conspicuous. There are 3 lateral inferomarginal spines, but they are stouter and shorter than in the adult. The fourth spine is wanting except on the first 2 or 3 plates. The subambulacral spines vary in number from 2 to 4 but only 2 are of any size and 1 of these is conspicuously larger than its adoral companion.

Type.—Cat. No. 30510, U.S.N.M.

Type-locality.—Station 5157, off Tinakta Island. Tawi Tawi Group, Sulu Archipelago, 18 fathoms, fine sand.

Distribution.—Sulu Archipelago to southern Luzon, east coast of Palawan, and east coast of Mindanao, in 14 to 44 fathoms, sand and mud. The known distribution centers, therefore, in the shallow environs of the Sulu Sea.

Specimens examined.—Forty-six from the following localities:

Specimens of Astropecten phragmorus examined.

Station.	Locality.	Depth.	Nature of bottom.	Number.
		Fathoms.		
5104	China Sea, off southern Luzon	33		1
5156	Off Tinakta Island, Tawi Tawi Group	18	Sand, shells	1
5157	do	18	do	12
5158	do	12	do	1
5161	do	16	Fine sand	1
5181	Off eastern Panay	26	Mud, fine sand	9
5235	Off east coast of Mindanao	44	Soft mud	1
5342	Malampaya Sound. west side of northern Palawan Island	14–25	Gray mud	15
5358	Sulu Sea, off Sandakan Harbor, Borneo	39	Mud	2
5426	Off east coast Palawan (lat. 9° 12′ N.; long 118° 28′ E.)	27	Fine gray sand	2
	Sandakan Bay, Borneo	2	Sand, rocks	1

Remarks.—The differences separating this form from *acanthifer* of the Banda Sea have already been dealt with. The only species which has longer superomarginal spines than *phragmorus* is the well-known *Astropecten polyacanthus.* No species of the Indo-Pacific region, other than *polyacanthus*, has the superomarginal spines as long as those of *phragmorus.*

ASTROPECTEN MINDANENSIS Döderlein.

Plate 10, fig. 2.

Astropecten mindanensis DÖDERLEIN, 1917, pp. 52, 131, 178, pl. 4, fig. 8; pl. 12, figs. 3–3*c*.

Diagnosis.—Similar to *Astropecten andersoni* Sladen, but with narrower rays, and the longer superomarginal spines all close to the inner margin of the plate; proximal inferomarginal lateral spines broad and flat. R=3.8 to 5.5 r; breadth of ray at base about equal to r.

Description.—The original description is substantially as follows: R:r=30:9 mm.; R=4.3 r. The rays taper rather uniformly from the base to the extremity. R equals from 3.8 to 4.4 r. The superomarginal plates are extremely narrow, and throughout much higher than broad. The paxillar area, opposite the fifth superomarginal plate, occupies two-thirds of the total breadth of the ray. Here 5 transverse series of paxillae correspond to 2 marginal plates. The central spinelets of the paxillae (upward of 12) are appreciably smaller than the peripheral spinelets. The superomarginal plates are not very thickly covered with coarse, flat squamules, which are much thicker than the paxillar spinelets, and they all carry a rather small, conical, somewhat flattened spine close to the inner edge of the plate, but separated from it by 1 to 3 rows of granules [original description, 2 or 3]. The inferomarginals are thickly covered with somewhat lengthened, broad, mostly acute squamules, without spinules on the aboral border of the plates. The large marginal spine, as long as 3 plates, is flat, broad and only slightly tapered, but has generally a sharp point. Under it is a much smaller flattened spine, and below this 2 or 3 much shorter ones still.

There are 2 actinal intermediate plates [4 to each interradius]. There are 5 furrow spines, of which the median is somewhat lengthened. Of the 2 spines of the second row, the aboral is not longer, but is very flat and broad, and rather acute, while the adoral is comparatively very small. On the outer part of the plate are several small spinelets.

Type-locality.—Mindanao.

Distribution.—Palawan, Samar, and Mindanao.

Specimens examined.—Fifty-eight from the following localities:

Mantaquin Bay, Palawan, 4 feet; 1 specimen.

Catbalogan, Samar, shore; 1 specimen.

Catabato, below mouth of Mindanao R., Mindanao, 6 feet, sand and mud; 3 specimens.

Station 5345, Malampaya Sound, Palawan Island, 7 fathoms, mud; 53 specimens.

Locality doubtful, 1 specimen.

Remarks.—The largest specimen has R=55 mm., r= 10 mm., R=5.5 r. A smaller example has R=30 mm., r=7 mm., R=4.3 r. There is some variation. There are usually 1 to 5 central paxillar spinelets in the *Albatross* specimens, and the major subambulacral spine is generally a little longer than the median furrow spine. The proximal inferomarginal plates sometimes have an incipient fasciculate pedicellaria near the inner end of the plate. There is considerable variation in the frequency of the spinules below the minor marginal spine.

Döderlein separates this species from *andersoni* and *debilis* as follows:

a^1. Spines of the superomarginal plates all very close to the inner margin of the plate and at least as long as the plate. The large inferomarginal spine on the proximal part of ray broad and flat__________*mindanensis.*

a^2. Spines of the distal superomarginal plates on the outer margin of plate and shorter than the plate. Large inferomarginal spine slender throughout ray.

  b^1. Squamules of inferomarginals longer than broad______________*andersoni.*

  b^2. Squamules of inferomarginals circular__________________________*debilis.*

ASTROPECTEN VAPPA INAEQUALIS, new subspecies.

Diagnosis.—Differing from *Astropecten vappa* Müller and Troschel[1] in having slenderer rays, a noticeably narrower paxillar area, very unequal subambulacral spines in the first series, the aboral being much longer and broader than the adoral spine, and in having more delicate, rather less granuliform superomarginal spinelets. R = about 62 mm., r = about 15 mm., R = about 4 r; breadth of ray at base, 16 mm.; breadth of paxillar area on same transverse line, at second superomarginal, 7 or 8 mm.

Description.—Paxillae compact, close set, the larger at base of ray and adjacent portion of disk, with about 15 terete peripheral spinelets and upward of 12 central shorter, somewhat thicker ones. Across the ray from one second inferomarginal to the opposite side, 10 to 12 paxillae can be counted. There are about 2 rows of paxillae to each superomarginal.

Superomarginal plates about 36, their proportions and major spines as in *vappa.* There is a series of short conical spines extending the whole length of the ray, the first on the inner margin of the plate, while the next 4 or 5 are successively nearer the middle of plate, an approximate position maintained by the remainder of the series. Central spinelets of dorsal face of plates appreciably coarser and shorter than those of lateral face, and slightly coarser than the central spinelets of paxillae.

There are 2 lateral inferomarginal spines (the lower about two-thirds or three-fourths the length of the upper), sharp, somewhat flattened on the basal third of ray. They are usually accompanied by 2 to 4 squamiform spinules which stand on the adoral side of their bases. On the first 2 or 3 inferomarginals there are 3 to 5 flattened, broad, sublanceolate, appressed spinules, much shorter than the main lateral spines, in a row on the actinal surface of plate; on the rest of the plates of the proximal half of the ray there are 1 or 2 such spinules near the aboral border.

Actinal intermediate plates, 4 in each interradius.

The median adambulacral furrow spine is compressed and longer than the laterals. In the next row are 2 spines, of which the aboral is much the larger, flattened, strap-shaped, with a truncate or slightly rounded tip, and about 2 mm. long. The proximal spine of this series is situated slightly nearer to the furrow, and beyond the base of ray it is about 0.6 the length of the other, and very much slenderer. Back of this series are a few delicate spinelets.

Type.—Cat. No. 40124, U.S.N.M.

Type-locality.—Station 5174, vicinity of Jolo, 20 fathoms, coarse sand; 1 specimen.

---

[1] As described by Döderlein, 1917, p. 124, pl. 5, fig. 1; pl. 11, figs. 2, 2*a*, 3.

Distribution.—Known only from the type-locality.

Remarks.—I have based my comparisons of this form upon the figures and description given by Döderlein in his recent revision of *Astropecten* (Döderlein, 1917).

In the general appearance of the abactinal surface, *inaequalis* bears a close resemblance to the figure of *A. mauritiensis* (= *A. bengalensis* Döderlein) given by Koehler in his Shallow-water Asteroidea (Koehler, 1910*a*, pl. 5. fig. 7), except that in *inaequalis* the paxillar area is narrower. Döderlein on plate 5, figure 1, gives a clear figure of the dorsal aspect of a specimen of *vappa* from Sharks Bay, Australia. As compared with this, the paxillar field of *inaequalis* is much narrower, occupying only about half the total width of the ray at base, while in *vappa* it occupies two-thirds. Döderlein's figure 2*a*, plate 11, shows that the *adoral* spine of the inner subambulacral series is relatively much larger than in *inaequalis*. In *vappa* there are apparently more conspicuous and rather more numerous actinal inferomarginal spines in addition to the 2 lateral spines.

The present race seems to be more nearly related to *vappa* than to *acanthifer*, although the latter is found in the Banda Sea and near Flores, two localities geographically nearer than the habitat of *vappa*, which is recorded by Döderlein from southwest Australia and New South Wales. In *acanthifer* the marginal spines are all slenderer and the inferomarginal armature is more bristling. There is a well-developed, conical, sharp *actinal* inferomarginal spine instead of an aboral series of flattened, sublanceolate, appressed spinules.

ASTROPECTEN VELITARIS von Martens.

Plate 11, figs. 3, 4; plate 14, fig. 2.

Astropecten velitaris Von Martens, 1865, p. 360.—Sladen, 1889, p. 214.—Döderlein, 1896, p. 307, pl. 18, figs. 32, 32*a*; 1917, p. 159, pl. 6, figs. 5, 15, 16; pl. 15, figs. 3–3*a*.—Koehler, 1910*a*, p. 44.

Notes on Philippine specimens.—The largest specimen in the collection has R=32 mm., r=9 mm., R=3.55; another has R=32 mm., r=8.5 mm. There are numerous specimens nearly as large. These are not "young," for the gonads are well developed. If this form is true *velitaris*, as it seems to be, the idea that it is the young of *A. hemprichii*, or of some other species, may be definitely abandoned.

Most of the specimens have a stout conical superomarginal spine on the first plate only, but a small percentage have a spine on some of the second plates. Thus, one example has either 3 or 4 superomarginal spines in the interbrachia, while others have 2 or 3, or 2 to 4, or very rarely 4 in all the interbrachia.

Paxillar area compact; paxillae large, the bases oblong, with 6 short lobes on the papular areas of ray, and irregularly circular with 2 or 3 short lobes on papular area of disk; along median area of ray and center of disk they are broadly elliptical to roundish, entire, and on central part of disk much smaller and imbricated. Papulae are lacking in central area of disk and along median radial area of ray. Crown of larger paxillae at base of ray with 4 to 10 central, short, clavate, granuliform spinelets and 12 to 15 longer round-tipped peripheral ones.

The superficial superomarginal granules are subcircular, and stubby to appressed squamiform, and round tipped, becoming abruptly slender laterally. The inferomarginal plates extend slightly beyond superomarginals laterally. Inferomarginal armature spiniform and not squamiform as in *A. zebra*. The spines are also more numerous in the adult specimens. A fairly typical marginal plate from the middle of the proximal half of ray has a prominent, flattened, sharp, lateral spine at its upper and outer end, 2.5 plates in length. Immediately below it is a semicircle of 3 or 4 sharp, slenderer spines about two-thirds its length. Outside this, forming a concentric semicircle, still at outer end of plate, are 5 or 6 still smaller slenderer spinules, and extending transversely along plate a little aboral to middle is a straight series of 5 or 6 spinules, subequal, at outer end of series, to spinules of the second lateral auxiliary series, thence increasing slightly in length toward inner end of plate. The general covering of plate consists of spaced slender spinelets, sharp when dried, but blunt in alcoholic specimens.

The adambulacral armature consists of a long, median, curved, compressed furrow spine with a considerably shorter and slenderer one on either side. The subambulacral spines are in 2 series, the inner consisting of 2 tapering round-tipped spines a little longer than the lateral furrow spines, and the aboral the longer of the 2; behind these is a row of 3 or 4 smaller spinelets, or a group of 3 to 5. In small specimens only 2 are present. First mouth plate much compressed with 2 transverse series of about 10 spines each.

Actinal interradial areas extremely small. There are 2 fair-sized plates back of the mouth plates, and 1 or 2 additional plates to either side of these. The spinelets are closely coordinated and form in some cases incipient fasciculate or pectinate pedicellariae.

Mouth plates very narrow. Marginal series occupies only the inner half of each plate and consists of about 7 spines, cylindrical and blunt, increasing in length toward the inner, which is about as long as one-third or one-half interradial length of plates. There is a regular superficial series of 8 to 10 subequal tapering blunt spines which commonly touch over the suture like a gigantic pectinate pedicellaria. These spines are about as long as the lateral furrow spines and are sometimes a trifle flattened.

Madreporic body close to margin, partly concealed.

Color in alcohol, yellowish with a broad transverse band of faded brown at middle of ray.

Type.—Museum Berlin, No. 1504.

Type-locality.—South China Sea.

Distribution.—Formosa to Ceylon, northwest Australia, and Admiralty Islands. The Philippine stations are consequently within this area. The specimens recorded by me from the Hawaiian Islands are not *velitaris.* (See under *Remarks.*)

Specimens examined.—Seventy-five.

Specimens of Astropecten velitaris examined.

Station.	Locality.	Depth.	Nature of bottom.	Number.
		Fathoms.		
	Sandakan Bay, Borneo	Off beach.	Sand, rocks	59
5099	China Sea, off southern Luzon	30	Gray mud, sand	1
5156	Tawi Tawi Group, Sulu Archipelago	18	Fine sand, shell	4
5157	do	18	do	1
5158	do	12	do	4
5161	do	18	Sand	4
5182	Off eastern Panay	26	Mud, fine sand	1
5480	Vicinity of Surigao Strait (northeast Tacbuc Light, Leyte).	62	Fine sand	1

Remarks.—The specimens described above appear to belong to the same species as that figured by Döderlein (1896, pl. 18, figs. 32, 32*a*) from Amboina. Döderlein's largest example was only half the size of mine. The Philippine specimens are perfectly distinct from *A. hemprichii*, and whatever the relations may be with that species, it is certain that *velitaris* is not merely a young phase, for several of the larger specimens examined proved to be sexually mature. Koehler (1910*a*, p. 46) quotes Marenzeller's opinion that *velitaris* is a young form.

Koehler (1910*a*, p. 41) is correct in questioning my Hawaiian record of *velitaris.* The form described by me and recorded as *A. velitaris* is distinct and differs from true *velitaris* in having short tubercular spines on the distal superomarginals, spaced from the inner edge of plate, in addition to the much more conspicuous spine of the first superomarginal of each ray. The superomarginals are fewer and a little more massive, the paxillae relatively smaller, the inferomarginal spines fewer and in a single transverse series, the 2 outer to be classified as lateral spines; the spinelets are squamiform, as in *zebra*, and there is commonly but one series of subambulacral spines, 3 to a series, the aboral member enlarged. The mouth plates are slightly broader than in *velitaris* and the marginal series of spines extends farther toward the outer end of plate. The first adambulacral is not so much compressed.

The Hawaiian species differs from *A. hemprichii* in having a conspicuous spine on the first marginal plate, and a different inferomarginal and adambulacral armature. *A. scoparius* lacks the prominent interbrachial superomarginal spines, has larger paxillae and more numerous inferomarginal spines. In the arrangement of superomarginal spines the species is nearest *pugnax* Koehler and *mauritianus* Gray. From the latter it differs in several minor details, such as the adambulacral armature, with its enlarged subambulacral spine, the smaller paxillae, the regular transverse series of inferomarginal spines. *Pugnax* has large, crowded paxillae, an inferomarginal armature identical with *scoparius*, and a slightly different adambulacral armature.

Döderlein recently named the Hawaiian form which he placed in his revision of Astropecten in the "*vappa* group," along with *A. vappa*, *triseriatus koehleri*, *bengalensis*, *mauritianus*, *orsinii*, and *acanthifer*.

Astropecten hawaiiensis Döderlein, 1917, p. 51 (=*Astropecten velitaris* Fisher, 1906, p. 1005, pl. 1, fig. 2; pl. 2, figs. 2, 2*a*) may be diagnosed as follows: Similar in general appearance to a small *A. mauritianus*, but differing in having smaller paxillae, 2 lateral and 2 or 3 actinal inferomarginal spines, forming a single series near or on distal margin of plate, and in having 1 series of 3 (or less often 2) subambulacral spines, the distal conspicuously enlarged. Differing from *A. koehleri* in the characteristic arrangement of superomarginal tubercles and in the inferomarginal armature as well as in having smaller paxillae; perhaps more closely related to the latter. *Type-locality.*—*Albatross* station 4055, Hilo Bay, Hawaii, 50 fathoms, fine gray sand.

ASTROPECTEN GRANULATUS Müller and Troschel.

Astropecten granulatus MÜLLER and TROSCHEL, 1842, p. 75.—SLADEN, 1889, p. 215, pl. 35, figs. 3 and 4; pl. 39, figs. 4–6.—DÖDERLEIN, 1896, p. 305, pl. 18, figs. 30, 30*a*; 1917, p. 148, pl. 5, fig. 7; pl. 14, figs. 1, 3, 3*a*; pl. 17, figs. 2, 2*b*, 3.—KOEHLER, 1910*a*, p. 40; 1910*b*, p. 266.

One immature specimen from station 5382, Ragay Gulf, Luzon, 128 fathoms, mud.

This example has R=15 mm., r=5 mm. It agrees more closely with the figure of Sladen than with that of Döderlein (1896). The spinelets of the paxillae and superomarginal plates are slenderer and less granuliform than in Sladen's specimen, and the subambulacral spinelets are not so stumpy and broad. These are in a single series of 3, subequal or the middle slightly enlarged. The proportions of the superomarginal and inferomarginal plates and shape of rays conform to Sladen's figures. The more delicate spinulation may in some way be correlated with the unusually great depth at which the *Albatross* specimen was dredged.

The *Challenger* specimen was taken in the Arafura Sea at 28 fathoms, green mud. Koehler's example was taken at the Aru Islands in 8 to 10 meters, and Döderlein's at Thursday Island. The type-locality is not known.

ASTROPECTEN MONACANTHUS Sladen.

Astropecten monacanthus SLADEN, 1889, p. 216, pl. 33, figs. 7 and 8; pl. 37, figs. 10–12.—KOEHLER, 1910*a*, p. 37, pl. 3, figs. 9–11; pl. 5, fig. 11.—DÖDERLEIN, 1917, p. 150, pl. 14, figs. 5–5*b*; pl. 17, fig. 9.

Eight specimens from the following localities:

Station 5181, off eastern Panay, 26 fathoms, mud, fine sand; 2 specimens.

Station 5182, off eastern Panay, 24 fathoms, mud, fine sand; 1 specimen.

Station 5480, vicinity of Surigao Strait, 62 fathoms, fine sand; 2 specimens.

Station 5481, vicinity of Surigao Strait, 61 fathoms, sand, shells, gravel; 2 specimens.

Mantaquin Bay, Palawan, 4 feet, sand, 1 specimen.

Type-locality—East of Panay, Philippine Islands, 20 fathoms, mud (*Challenger* expedition).

Distribution.—Philippine Islands, Andaman Islands, east coast of India, Red Sea.

Remarks.—The largest specimen measures R=37 mm., r=10 mm.; the smallest, R=15 mm., r=5 mm. The 3 examples from stations 5181 and 5182, east of Panay, are practically from the type-locality. These conform to the figures and description given by Koehler of large specimens, and there seems to be no doubt that his examples are true *monacanthus*. Sladen's type is a rather small specimen.

The largest specimen, from station 5181, has a small tubercle on one of the first inferomarginal plates. The color is a light dull brown, with the center of disk and a narrow radial stripe reddish brown.

Astropecten monacanthus is readily recognized by its fairly large paxillae, unarmed granulate supermarginals (the granules flattened and sometimes squamiform), the close mail of rounded imbricating inferomarginal squamules, the single flattened to subterete lateral spine, with a small companion just below it, and the highly characteristic adambulacral armature. The latter consists of 3 flattened furrow spines truncate or round tipped, the median with edge to furrow. These are succeeded by 2 narrow flattened subambulacral spines, so placed as to appear to form an arc of 5 with the furrow spines. They are shorter than the lateral furrow spines, usually tapering and bluntly pointed. Commonly only the aboral one is present. Back of these are 2 very broadly spatulate round-tipped or truncate spines, about as long as the lateral marginal spines, the aboral slightly the larger. Sometimes the aboral member of the first actinal series moves back a little, broadens, and stands in line with the 2 spatulate spines, making a series of 3; or, as mentioned above, it may stand out of line. It then forms a curved series with the 2 spatulate spines.

The first 2 inferomarginals may have several squamules enlarged, and forming a transverse series of 2 or 3 accessory flat leaflike spinules in line with the accessory marginal spinule.

ASTROPECTEN EUCNEMIS, new species.

Plate 10, fig. 1; plate 14, figs. 3, 3*a–d*.

Diagnosis.—Rays 5. R=63 mm., r=9 mm., R=7 r (R : r, variable; see variations); breadth of ray at base (second superomarginal) 9.5 mm. A species with long, slender rays, usually unarmed superomarginals and large paxillae, resembling *A. granulatus*, from which, however, it differs in having longer, narrower rays, more delicate paxillar spinelets, a different inferomarginal armature, more numerous and longer subambulacral spines, and narrower mouth plates, with more numerous and more delicate oral spines.

Description.—Rays long and narrow, very gradually tapering; disk small, with a slight prominence in center; interbrachial angles abrupt; sides of ray rather high in proportion to width, especially at base. Paxillar area plane, except in center of disk; paxillae large and crowded, arranged in not very regular transverse bands on ray, 4 of the series corresponding to the second and third superomarginals. Pedicels cylindrical and slender, the crown very flaring and floriform, consisting, on the larger paxillae of disk, of a peripheral series of 10 to 16 terete, rather slender, round-tipped spinelets, encircling a central divaricate group of 5 to 12 similar but slightly shorter ones. On the outer third of ray the paxillae have about 5 to 8 peripheral and usually only one central spinelet.

Superomarginals (48 in number) without special spines, except sometimes a small tubercle on the first plate. They are wider than long, and form a rounded dorsal margin to ray. On the proximal half of ray the plates form more than half of the perpendicular lateral face of ray and decrease gradually in height, at the same time encroaching more and more upon the paxillar area, as the tip of ray is approached. There is some variation in the proportions of the superomarginal plates, but they are usually higher in the larger specimens. The fascioles are rather wide and abrupt between the plates and have a slightly oblique trend instead of being exactly transverse. Exposed surface of plates covered with close-set, broadly lanceolate appressed granuliform spinelets with rounded or bluntly pointed tips directed upward or distally.

Inferomarginals not extending laterally beyond superomarginals. Lateral spines 2, tapering and sharp, situated at outer end of plate, the upper the longer and equal to a little over 2 plates in length. Sometimes a third very much smaller spine is added at the inner end of series but is not constant. Spaced from the lateral spines, near inner end of plate and aboral margin is a smaller, sharp, flattened appressed spine a little longer than its plate; at the base of ray there are usually 1 to 3 additional similar spines forming a series continuous with the lateral spines. If the number of lateral spines is represented by Roman numerals and the accessory actinal marginals by Arabic, the spine formula for the first inferomarginal of type is O+4 or 5 or I+4 or 5; for the second, II+3 or 4; for the third II+2, 3, or 4; for the fourth, II+2, 3, or 4: from here it is II+2 usually or in those specimens in which the third small lateral is not developed, II+1. The inner actinal spinule usually disappears on the outer third of ray, while the accessory or third lateral persists, if it happens to be present at the base of ray. The spine formula for the outer third of ray is commonly II+1, or II+0. The general surface of plates is armed with spaced lanceolate sharp, or exceptionally, blunt flattened spinelets directed outward, 2 to 4 being enlarged and forming a series adorally to the lateral spines. These sharp spinules were not reckoned in the above formulas, as they stand entirely out of line of the transverse series.

Terminal plate rather small, about as wide as long with a notch at both distal and proximal ends, between which runs a shallow sulcus.

Adambulacral armature: (1) A furrow series of 3, the middle the longest, curved, compressed but slender, with sharp edge toward furrow, the laterals a little shorter only slightly flattened, slenderer, tapering, and pointed. (2) On the actinal surface, a longitudinal series of 3, the median about as long as the middle furrow spine, flattened and sharply or bluntly pointed, the laterals much slenderer, and about two-thirds as long as the median. Sometimes only 2 stand in this series. Back of these, 3 or 4 much shorter and slenderer spinules form a series or group. A large specimen (locality uncertain) has all the subambulacrals flattened and round tipped, the enlarged spine being spatulate. The first adambulacral is much compressed and bears 2 transverse contiguous rows of numerous slender spinules, and has no enlarged subambulacral, but the second plate, although compressed somewhat, bears an enlarged spine.

Mouth plates narrow and small, each traversed by 2 parallel series of spines; the marginal with about 15, small slender spines or spinules, similar to those of the first adambulacral, the inner 2, abruptly enlarged, flattened, and round tipped. The superficial spinules are slightly longer and stouter and the inner spine of each series is sometimes enlarged (as in type) forming 2 tiers of teeth (3 to a plate) at the inner angle.

Actinal intermediate plates 2 to 4, typically with a group of spinelets, the central ones sometimes coördinated to form a pedicellarian apparatus.

Madreporic body oval, medium sized, obscured by paxillae, some of which arise from its surface. It is situated less than its own diameter from marginal plates.

Color in alcohol, sepia.

Variations and young.—A well-marked variety probably from station 5134, 25 fathoms, perhaps deserve a name. It differs from the typical form in having coarser, more squamiform and blunter inferomarginal spinelets, 2 marginal spines, without a third smaller one directly below and frequently only 1 spine on the actinal surface of plate. As a result the inferomarginals appear less spiny. The first superomarginals have a small tubercular or clavate spine at the upper end, and the second and third plates show an incipient one. The rays are very long, but all are incomplete. The proportions would probably be: R=about 8 r.

Twenty-nine small specimens ranging in size from R=9.5 mm. to R=19 mm., all from station 5182, seem to be a small variety of this species, although at first they appear to be quite distinct. Coming from shallow water they resemble more closely the aberrant example from station 5134, but have much shorter rays. These small examples recall both *Astropecten zebra* and *A. granulatus*, but the distinguishing marks are given below.

The largest specimens have R=19 mm., r=5 mm., R=3.8 r; breadth of ray at base, 5 to 6 mm.; rays tapering evenly to pointed extremity; superomarginals about 20 to 24, forming a rounded bevel to margin, and not encroaching upon paxillar area farther than in adult. Sixteen specimens, ranging in size from R=9.5 mm. to R=19 mm. have no sign of special superomarginal spines; 6 specimens varying from R, 17 to 19 mm., have a small tubercle on some but not all of the first superomarginal plates; 1 or 2 have tubercles on the second plates in 1 interbrachium; 7 examples of the same size have 2, 3, or 4 (more often only 2) short tubercular superomarginal spines in each intebrachium. The specimens with R over 17 mm. have gonads fairly well developed. The inferomarginal armature consists of 1 marginal spine and a shorter companion, and a few specimens show the rudiments of the actinal spines. The armature is similar to Sladen's figure of *A. granulatus* but the spinelets are slightly less squamiform. Ten out of the 13 specimens with superomarginal spines have 2 pectinate actinal intermediate pedicellariae, just back of the mouth plates.

Of the 16 lacking superomarginal spines, only the 2 largest (R=19 mm.) have the pedicellariae; the other 14 (with R less than 14 mm.) either lack the pedicellariae, or have them in a very incipient stage. The outer row of subambulacral spinelets is lacking in these small specimens, otherwise the armature is very similar to that of the large examples. The paxillae have 1 or 2 central and 8 to 12 peripheral spinelets, relatively shorter and stouter than in the adult. The terminal plate has 4 terminal conical spinelets.

These small specimens differ from *Astropecten granulatus* in having narrower superomarginals, which form a narrower border to paxillar area, and distally narrower rays which taper evenly to a point (not swollen); in having often small interbrachial superomarginal spines and large pectinate actinal interradial pedicellariae, very much smaller mouth plates and a much slenderer terminal plate. The inferomarginal armature is similar but the spinelets of *granulatus* as figured by Sladen are a little more squamiform.

The specimens with superomarginal spines might be taken for *A. zebra*, but they have narrower superomarginals, smaller paxillae, fewer inferomarginal spines and less squamiform spinelets, smaller mouth plates and a slightly different adambulacral armature. Very young *monacanthus* has the curious chaffy inferomarginal spinelets of the adult, only one marginal spine, and the very characteristic broad spatulate subambulacral spines. It lacks, of course, the superomarginal spines.

It remains to add that one of the most striking features of this species is the rapid increase in the length of ray relative to disk as the animal grows. The smallest of the deep-water typical specimens measures: R, 42 mm., r 7.5 mm., R=5.6 r; the next size has R, 52 mm.; r, 8 mm.; R=6.5 r. In the type R=7 r and in the large shallow-water variety R=about 8 r.

Type.—Cat. No. 37005, U.S.N.M.

Type-locality.—Station 5393, between Samar and Masbate Islands, Philippine Islands, 136 fathoms, hard sand.

Distribution.—From Masbate Island, Philippine Islands, to Sulu Archipelago, the last locality somewhat doubtful. Typical form in 108 to 136 fathoms, sand; varieties in shallow water.

Specimens examined.—Typical, 4: from the type-locality, 3, and 1 from station 5212, between Masbate and Talajit Islands, Philippine Islands, 108 fathoms, gray sand, mud.

Twenty-nine small specimens from station 5182, off eastern Panay, 24 fathoms, fine sand and mud. At this station were taken also *A. velitaris* and *A. monacanthus.*

One large specimen, not typical, from station 5134, Sulu Archipelago, near Basilan Island, 25 fathoms, fine sand; this locality is marked doubtful.

Remarks.—This species resembles most nearly *Astropecten granulatus* as redescribed by Sladen. The fully grown typical specimens differ from *granulatus* in having much longer, narrower rays, a different inferomarginal armature and smaller mouth plates. The differences between the small specimens and *granulatus* have been detailed under "Variations."

Astropecten notograptus Sladen from the Mergui Archipelago bears some resemblance to the young of this species. Sladen's type measures R, 16.5 mm.; r, 6 mm. It differs, however, in having much larger paxillae, with short granuliform armature, and broader superomarginals (which, like some of the young *eucnemis*, have a tubercle on the first member); in having the marginal plates and adambulacral armature very closely resembling that of young *Astropecten monacanthus*, even to the characteristic spatulate subambulacral spines. The inferomarginal spinelets are, therefore, very squamiform. In fact, *notograptus* is extremely close to *monacanthus*.

This species falls in the monocanthus group of Döderlein, who subdivides the section on the presence of inferomarginal spines on the aboral edge of the plate (*granulatus*, *orientalis*); or on the absence of such spines (or "mit undeutlichen Stachelen—die ersten 2 Platten können kurze Stacheln tragen"). The second subsection includes *monacanthus*, *notograptus*, *granulatus*, *indicus*, *bonnieri*, *sarasinorum* new, *malayanus* new, *umbrinus*, *pusillus*. *A. eucnemis*, with its long rays and inferomarginal spines, is quite distinct from either *orientalis* (having broad, heavy superomarginal plates) or *granulatus*.

ASTROPECTEN EREMICUS Fisher.

Plate 13, fig. 2; plate 15, figs. 3, 3*a–e*.

Astropecten eremicus Fisher, 1913*a*, p. 605.—Döderlein, 1917, pp. 50, 175.

Diagnosis.—Disk small, rays flexible and fairly long; relation of R to r variable, in type, R=51 mm., r=9 mm., R=5.66 r; breadth of ray at base, 11 mm. Paxillae small, not crowded, and with few spinelets; abactinal spiniform pedicellariae; superomarginals unarmed, wholly abactinal; inferomarginals extending laterally beyond superomarginals; lateral spines 2, the upper the longer, and equaling about 2.5 plates in length, and in addition an actinal marginal spine near the adambulacral plates (on proximal half of ray); adambulacral plates with 4 or 5 slender furrow spines, and 5 or 6 similar subambulacral spines in 2 longitudinal series; sometimes a prominent subambulacral pedicellaria with 4 to 6 spiniform jaws is present.

Description.—Paxillar area narrow on ray. Paxillae small and spaced, with slender, relatively high pedicels bearing a few cylindrical delicate blunt membrane invested spinelets, slightly shorter to slightly longer than pedicel, the whole about 1 mm. high. Each paxilla has a broadly elliptical base and 5 to 8 spinelets, of which one usually occupies the center, except on the distal half of the ray, where the paxillae are smaller, and have 4 or 5 spinelets, or at tip as few as 2. There is usually, but not always, a slight prominence at center of disk. The papulae extend about half the length of ray. Scattered over abactinal surface are fairly numerous pedicellariae borne on special plates, and with usually 4 spiniform jaws nearly as thick as the pedicel of a paxilla.

Superomarginals (36 to 38) dorsal in position (the upper ends of the inferomarginals forming the margin to ray) and forming a conspicuous, slightly rounded border to the paxillar area. The plates are proximally wider than long but on outer portion become slightly longer than wide. They bear no special spines but are covered with slightly spaced lanceolate pulpy spinelets very sharp on central portion of plate (where they are directed toward end of ray), but blunt on the edge. Here they close over the deep fasciolar grooves, lined with capillary spinelets. As in the case of the paxillae, the calcareous spinelet is really very delicate and the various proportions and shapes of the superomarginal papillae are due to the membranous investment.

Terminal plate fairly large, notched at tip and with deeply concave margin toward paxillar area. The surface is covered with minute spinelets, and in addition 8 needlelike spines, 4 on either side at the tip, the 2 central ones of each series being the longest, and usually a little longer than the plate, as seen from side.

Inferomarginals extending laterally beyond superomarginals about half the width of the latter and forming a beveled border to actinal surface. The width of the plates equals about the length of 2, including the fasciolar groove. General surface covered with large spaced pulpy lanceolote spinelets which abactinally become much smaller and grade into the superomarginal spinelets. These spinelets are directed outward and aborally, and are usually sharp, except at inner end of plate. Lateral spines, usually 2, the outer and upper (on the upper end of plate) the longer (equaling 2.5 plates in length) tapering, flattened, and very sharp. The second, about two-thirds to three-fourths the length of the first, is spaced from it slightly, and is much slenderer and more nearly cylindrical, although flattened obviously at the base. Rarely a smaller spine makes a third in this series. Rather nearer the inner edge of plate than base of second lateral spine, is a much shorter and more delicate spine, which is well-developed only on the proximal half of the ray. It is analogous to the inner inferomarginal spine of *A. phragmorus*.

Ambulacral furrow wide; tube feet large, with sharp point. Adambulacral plates with wide sutures and strongly convex furrow margin, which bears (instead of the usual number of 3) 4 or 5 long, slender, tapering, pointed, membrane-invested spines, that on the apex of the angle the longest and a trifle flattened. The subambulacral spines are slightly shorter, and although the calcareous portion is slender and needlelike, the light brown pulpy, translucent investment is swollen (as in all the other actinal spinelets), so that the spinelets appear to be stout clavate, and pointed. There are usually about 5 (as many as 7) in 2 longitudinal series, or less often irregularly placed. A variable number of plates (for instance 5 to 7 on either side of a furrow) bear a conspicuous conical pedicellaria with 4 to 6 lanceolate spiniform jaws, very much stouter, but shorter, than the subambulacral spines, which the pedicellaria partly or wholly replaces on its particular plate. These pedicellariae are similar to those on the paxillar area. The first adambulacral is considerably compressed and often bears a pedicellaria.

Actinal intermediate plates very few (about 6) their 5 or 6 spinelets coordinated to form a pedicellarian apparatus similar to those of the adambulacral plates. Occasionally the spinelets are not quite so specialized, as if in a transition stage from a low paxilla to a pedicellaria.

The combined mouth plates narrow, but 4 enlarged teeth at inner angle (the 2 median the longer), and 3 or 4 spines of about the same size at the outer angle of each plate. Between the two groups, the plates are covered with smaller spinelets, the superficial the largest, those toward edge decreasing in size. On either side of the median suture on some plates these spinelets are arranged in a fairly regular series, with about 2 additional irregular series toward the margin. The true marginal spinelets are small, save for the teeth, and form an angular series, with the angle at the inner end of the plate near the teeth. The armature of the mouth plates is rather confused and irregular. The enlarged outer superficial spines are characteristic.

Madreporic body small and partly or wholly hidden by paxillae. It is situated close to the superomarginal plates, sometimes nearly touching them, sometimes its own diameter distant. The striae are few, coarse, and are nearly parallel with interradial line.

The general color is a light brown, darkest on the actinal surface, or a washed-out yellow ochre. In the darker specimens the color is lodged in the epidermis investing the spinelets.

Type.—Cat. No. 30511, U.S.N.M.

Type-locality.—Station 5491, Surigao Sea, between Leyte and Mindanao, 736 fathoms, green mud and coral.

Distribution.—Off southern Luzon to Surigao Sea, between Leyte and Mindanao, 530 to 736 fathoms.

Specimens examined.—Ten from the following Philippine localities:

Station 5219, between Marinduque and Luzon, 530 fathoms, green mud; 2 specimens.

Station 5491, Surigao Sea, between Leyte and Mindanao, 736 fathoms, green mud, coral; 1 specimen.

Station 5492, Surigao Sea, between Leyte and Mindanao, 735 fathoms, gray mud; 3 specimens.

Station 5494, Surigao Sea, between Leyte and Mindanao, 678 fathoms, green mud, sand; 4 specimens.

Remarks.—*Astropecten cremicus* resembles in general appearance *A. luzonicus* and *A. tenellus*, from which it differs in the entire absence of superomarginal spines, in regularly having 4 or 5 furrow spines, as well as in several special features detailed under each of the above species. The absence of superomarginal spines and the presence of abactinal, actinal intermediate, and subambulacral pedicellariae will suffice to distinguish *cremicus* from *A. griegi* Koehler, also a deep-water species with slender rays. There is a great resemblance between *cremicus* and *A. pusillulus* Fisher from the Hawaiian group. Both have slender rays, and the same type of slender spinelets with a brownish pulpy investment. *Pusillulus* has but 3 furrow spines, the median stouter and wider than in *cremicus*, being much flattened; paxillae with lower pedicel and shorter spinelets; no actinal inferomarginal spine in addition to the two lateral spines (except sometimes on the first 2 or 3 plates); shorter rays and relatively larger disk. *Pusillulus* lacks abactinal pedicellariae, but has adambulacral and actinal intermediate ones similar to those of *cremicus*. I think the two species are closely related. (See Fisher 1906, p. 1008, pl. 1, fig. 3, pl. 2, fig. 4, 4*a*–*b*.)

ASTROPECTEN LUZONICUS Fisher.

Plate 12, fig. 2; plate 13, fig. 3; plate 14, figs. 4, 4*a*–*b*.

Astropecten luzonicus Fisher, 1913*a*, p. 606.—Döderlein, 1917, pp. 50, 175.

Diagnosis.—Similar to *A. cremicus*, but with longer, narrower rays; a small tubercular spine on the first few superomarginal plates; only 3 furrow spines beyond the first 5 or 6 plates; armature of each mouth plate in 2 regular longitudinal series. Disk very small, rays long, slender, and very flexible; paxillar area narrow; paxillae small, delicate; lateral spines 2 or 3; furrow spines 3; subambulacrals 2 to 4, none enlarged.

Type, R=68 mm., r=9 mm., R=7.55 r; breadth of ray at base, 9 to 10 mm.

Description.—Paxillae small and spaced, very similar to those of *Astropecten cremicus*, having a slender pedicel, capped by 5 to

8 slender, blunt membrane-invested spinelets, as long as or slightly longer than the pedicel, which springs from a broadly elliptical base—one conspicuously larger than the caliber of the pedicel. Paxillae fairly uniform in size except on low eminence in center of disk, and far along ray, where they are smaller and lower, those on the outer third of ray having 5 to 2 spinelets. Papulae absent from center of disk and median area of ray. They extend along either side of the ray in a narrow band as far as the middle. The paxillar area is narrow, beyond the middle occupying but a little over the median third of the entire width of ray. Pedicellariae, similar to those of *eremicus*, but smaller, are present among the paxillae, but are very few and inconspicuous.

Superomarginal plates, about 55 to each side of the ray, similar to those of *A. eremicus* in form and position, but the central spinelets are not sharp and squamiform as in *eremicus;* rather, they are blunt and clavate, or cylindrical.

The first 5 to 10 plates bear, at the upper end of the plate, slightly spaced from the inner edge, a small upright conical, sharp, tubercular spine. This rapidly decreases in size and merges into the spinelets, and may be lacking on the first superomarginal.

Terminal plate similar to that of *A. eremicus*, with 2 to 4 slender spines on either side of the tip.

Inferomarginal plates similar to those of *A. eremicus*, forming the margin of ray and covered with coarse, spaced, sharp pulpy spinelets. Lateral spines, 3 proximally and 2 distally, the upper, the longer and stouter, being sharp, flattened and narrowly lanceolate. The others are narrower and shorter, the lowest (when there are 3) being the smallest. In some specimens only the first few plates have 3 lateral spines, the rest having 2; and one large specimen (station 5363) has only 2 throughout. The small spine near the inner end of the plates of *A. eremicus* is lacking except rarely on the first 2 or 3 plates. Six or 8 plates, scattered throughout each side of the ray of type, bear a large spiniform pedicellaria with 4 to 6 jaws near the inner end. This is either absent or of very rare occurrence in the other specimens.

Adambulacral plates with 3 furrow spines (except on first 5 to 7 plates where there are 4), the middle spine conspicuously the larger, blunt, flattened, and saberlike, the laterals slenderer, subterete, and pointed. The actinal surface of the plate, which is not extensive, bears 2 to 4 shorter, sharp spinelets in 1 or 2 series; none of them are especially enlarged, so that they are subequal, or one on outer part of plate may be much smaller.

Owing to the pulpy investment the caliber of the subambulacrals is variable—sometimes slender, sometimes stout. No subambulacral pedicellariae.

Actinal intermediate plates 5 or 6, each with a spiniform pedicellaria with 4 to 6 jaws.

Mouth plates similar to those of *A. eremicus* but the spines in two definite, regular longitudinal series to each plate, not irregular. Marginal series angular with 7 or 8 spines, slightly shorter than the lateral furrow spines, the 2 inner abruptly enlarged to form stout, blunt teeth; the series is continued adjacent to first adambulacral in about 5 little spinelets. The superficial series contains 7 or 8 much thicker, bluntly pointed, lanceolate spines (in line with the inner tooth) the outer 1 or 2 slightly enlarged.

Madreporic body near to but not touching superomarginals. It is small, partly obscured, and crossed by few, coarse striae radiating from the middle of the adcentral side.

Color in alcohol, bleached yellowish or brownish.

Variations.—The chief variations in armature have already been indicated. It remains only to point out that the smaller specimens have relatively shorter rays, although still slender. A specimen from station 5112 measures as follows: R=35 mm., r=6 mm., R=5.8 r; breadth of ray at base, 6 mm.

Type.—Cat. No. 30512, U.S.N.M.

Type-locality.—Station 5112, Balayan Bay, southern Luzon, 177 fathoms, dark green mud, bottom temperature 52.4° F.

Distribution.—Off southern Luzon, Philippine Islands.

Specimens examined.—Seven from the following stations:

Station 5111, Balayan Bay, southern Luzon, 236 fathoms, green mud; 1 specimen.

Station 5112, same locality, 117 fathoms, dark green mud; 4 specimens.

Station 5363, same locality, 180 fathoms; 1 specimen.

Station 5365, same locality, 214 fathoms; 1 specimen.

Remarks.—This species, while resembling *Astropecten eremicus*, differs in having longer and slenderer rays, small tubercular spines on the first few superomarginal plates, only three furrow spines, no adambulacral pedicellariae, mouth plates with two regular lengthwise series of spines, no small spine near the inner end of the inferomarginal plates, very few abactinal pedicellariae, terete, or clavate spinelets on the surface of the superomarginal plates. The mouth spines are not irregular, but arranged in two regular longitudinal series on each plate.

ASTROPECTEN TENELLUS Fisher.

Plate 11, figs. 1, 2; plate 15, figs. 1, 1*a*–*b*.

Astropecten tenellus FISHER, 1913*a*, p. 606.—DÖDERLEIN, 1917, pp. 50, 176.

Diagnosis.—Very similar to *Astropecten griegi* Koehler, from which it differs in having a few abactinal pedicellariae among the paxillae; in lacking a special spine on the distal superomarginals; in having very sharp, flattened inferomarginal spinelets, and proximally several spinules along the aboral edge of the inferomarginal plates ventral to the lateral spines; in having the median furrow spine conspicuously flattened, not cylindrical; in having proximally adambulacral pedicellariae. Disk small, rays long and slender. R=108 mm., r=10 mm., R=10.8 r; breadth of ray at base, 11 mm. A smaller specimen, however, measures as follows: R=48 mm., r=6 mm., R=8 r.

Description.—Paxillar area very narrow on rays, as is *griegi.* Paxillae fairly compact, with a rather stout pedicel surmounted by a tuft of delicate, cylindrical, blunt spinelets slightly longer to slightly shorter than the pedicel. Commonly there is a central spinelet surrounded by 8 to 12 on the periphery of pedicel; far along the ray the paxillae become lower, and the spinelets are fewer. There are a few pedicellariae with about 4 upright spiniform jaws, shorter than the paxillae, scattered over disk and proximal portion of ray.

Superomarginals forming a conspicuous arched bevel to abactinal area, dorsal in position, proximally wider than long, distally longer than wide, covered with small, spaced, bluntly pointed spinelets usually a little larger, more squamiform, and appressed on center of plate. In *griegi* these spinelets are extremely short in the median region, becoming longer toward the transverse margins; in *tenellus* they are the reverse. The plates bear a tapering, slightly flattened, sharp spine about as long as the plate on the upper (or inner) end and aboral margin. Rarely there are 2 spines. This spine is lacking from the terminal fourth or fifth of the ray. In *griegi* the spine seems to continue to the end of the ray.

Inferomarginals covered with coarse, lanceolate, mucronate, squamiform appressed spinelets, or in small specimens with slenderer, more terete, and pointed ones. They bear 3 or 4 conspicuous, slender, flattened, sharp, lateral spines placed as in *griegi* at the upper end of plate along the aboral edge; and continuing this series to the inner end of plate are, on the proximal plates, 3 to 5 shorter, slenderer, spinules evidently enlarged from the spinelets covering the plate. Distally these spinules are scarcely more than slightly enlarged spinelets, and are few in number and of irregular occurrence.

Adambulacral plates well spaced and rather short. Furrow spines 3, rather long, the median slightly the longest, flattened, saber-shaped and pointed, the other two more cylindrical, slenderer, tapering, and pointed. Subambulacral spines: Back of the furrow series, a slightly oblique longitudinal series of 3, the aboral the largest, and usually longer than the median furrow spine; the others are decreasingly shorter. Back of these there are 3 to 5 shorter, slender spinules either in a series or irregularly placed, which grade the spinulation of the adambulacrals into that of the inferomarginals. Sometimes the enlarged subambulacral stands on the furrow margin, appearing to form one of the furrow series. A few proximal plates may have 4 furrow spines (not counting a subambulacral out of position). In a specimen from station 5518 the first and second plates bear a conspicuous conical subambulacral pedicellaria composed of about 6 spines. The type has 1 or 2 and a cotype has several, so that it seems to be a constant character.

The actinal intermediate plates are few and bear a tuft of spinelets about as long as the outer subambulacrals or a conical spiniform pedicellaria. Pedicellariae are not mentioned in the description of *griegi*.

The armature of the mouth plates (which are of the type of *eremicus* and *luzonicus*) consists of a marginal series of 7 or 8, increasing in length toward the inner end of the plate—the combined plates having either 4 or 6 enlarged, blunt teeth. The superficial spines are not in regular series, are numerous, and coarse. They correspond to about 2 series.

Madreporic body less than its own diameter distant from superomarginal plates and nearly obscured by paxillae.

Type.—Cat. No. 30513, U.S.N.M.

Type-locality.—Station 5453, Albay Gulf, east coast of southern Luzon, 146 fathoms.

Distribution.—Southern Luzon to Mindanao Sea, Philippine Islands, 146 to 200 fathoms.

Specimens examined.—Eight: 4 from the type-locality; 2 from station 5518, Mindanao Sea, off Point Tagolo, Mindanao, 200 fathoms, gray mud, globigerina, bottom temperature, 54° F.; and 2 from station 5268, Batangas Bay, Luzon, 170 fathoms, sand and shells.

Remarks.—The differences between this species and *A. griegi* (Bay of Bengal, Indian Ocean, 130 to 464 fathoms) have been mentioned in the diagnosis and description. It differs from *A. eremicus* in having much longer, slenderer rays, superomarginal spines, only 3 furrow spines, and an enlarged subambulacral spine; and from *luzonicus* in having the superomarginal spines extending far along ray, not confined to the base; in having larger paxillae, fewer subambulacral spines, of which 1 is enlarged, no inferomarginal pedicellariae, a few proximal subambulacral pedicellariae, and a row of accessory inferomarginal spinules, below the lateral spines. The superficial mouth spines are more numerous, and not in a single, regular series, as in *luzonicus*.

Astropecten imbellis Sladen from 100 fathoms off Tablas Island, Philippine group, is a young form: Of the 4 species *eremicus*, *luzonicus*, *tenellus*, and *pedicellaris* I think it can be confused only with *tenellus*, which it resembles in having the superomarginal spines extending as far as the middle of ray. This would cut out *eremicus*, which entirely lacks superomarginal spines, and *luzonicus*, in which the spines occur only at the base of ray. If, however, a small specimen of *luzonicus* (R=30 mm., r=6 mm., R=5 r) only slightly larger than Sladen's type is compared with his figures and description the following additional differences are evident. In *luzonicus* the rays are much slenderer, the paxillar area narrower, and such superomarginal spines as are present, shorter. There are 2, not 3 or 4, lateral spines, the superficial mouth spines are conspicuously stouter than the lateral marginals and in a single series. The median furrow spine is strongly compressed and longer than the laterals.

There is a specimen of *tenellus* with R = 22 mm., r = 4.5 mm., R=slightly less than 5 r. (In *imbellis* R=24 mm., r=7 mm., R = 3.43 r.) The rays of *tenellus* are longer and slenderer than those of *imbellis*, even though the specimen is smaller, the paxillar area is relatively narrower, one of the subambulacral spines is conspicuously enlarged and all are longer than in *imbellis*, interradial pedicellariae are present, and the inferomarginal spinelets are spaced, sparser, sharp, and closely appressed. The aboral line of accessory spinules characteristic of the adult has begun to develop.

The numerous pedicellariae of *pedicellaris*, as well as its proportions and adambulacral armature will serve to distinguish it from *imbellis*.

ASTROPECTEN PEDICELLARIS Fisher.

Plate 12, fig. 1; plate 13, fig. 4; plate 15, figs. 2, 2*a*–*e*.

Astropecten pedicellaris Fisher, 1913*a*, p. 607.—Döderlein, 1917, pp. 50, 176.

Diagnosis.—Similar in general appearance to *A. tenellus*, but differing in having abundant abactinal and adambulacral pedicellariae as well as pedicellariae on superomarginal and inferomarginal plates, smaller paxillae, narrower superomarginal plates, and more prominent lateral spines, which are 4 in number, except on outer third of ray, where 3 are present. Rays long and slender; paxillar area narrow. R=74 mm., r=9 mm., R=8.2 r; breadth of ray at base, 9 to 10 mm.

Description.—Paxillae similar to those of *A. eremicus*. Spinelets terete, blunt, usually as long as or a trifle longer than pedicel; and on the largest paxillae of interradial areas there is 1 central spinelet and 9 or 10 in a peripheral series; halfway along ray there are 6 or 7 in a peripheral series and no central spinelet. Scattered over the paxillar area are numerous conical pedicellariae with 3 to 6 blunt, tapering, spiniform jaws which are slightly longer than the pedicels of paxillae.

Superomarginals, 43 to 44 (on longest ray), slightly longer than wide, except at base of ray, and covered with short spinelets, slightly flattened, lanceolate, and blunt on center of plate, slenderer and terete at sides. Each plate on the proximal three-fourths of ray bears, at the upper end slightly aborally from center, a conical sharp spine (as in *tenellus*), about as long as the plate. Most of the plates bear also, near the center, a low, dome-shaped, fasciculate, pedicellaria composed of 4 to 8 slightly modified stubby spinelets. These pedicellariae are somewhat irregular in position and 2 are occasionally present. Their spinelets are thicker than the neighboring spinelets.

The inferomarginals extend laterally beyond the superomarginals defining the border of ray, as in *eremicus*, *luzonicus*, and *tenellus*. Lateral spines 4, or 3 on outer third, slender, tapering, sharp, and sometimes slightly curved; and, in addition, the plates of the proximal third continue the series to the inner end of plate, with 1 or 2 shorter, slenderer, but well-developed spinules. The uppermost spine, or the second, is the longest and proximally equals 2.5 plates. The spinelets of the inferomarginals are coarse, tapering, and bluntly pointed. Most of the proximal plates bear a small fasciculate pedicellaria at the upper end, near the base of the first spine; and on the ventral surface of nearly all the plates are 1 to 3 similar but larger pedicellariae.

Adambulacral armature: (1) Furrow spines, 3, the median compressed and thin, with a rounded, or blunt, point, the laterals a trifle shorter, tapering, and much slenderer. (2) On the actinal surface, back of the furrow series, a series of 2 or 3 spines similar to those of *tenellus*, the aboral member enlarged, tapering, slender, flattened, blunt-pointed and a little longer than median furrow spine; behind these are 3 to 5 shorter spines. Instead of this arrangement, many plates have the subambulacrals nearly equal and grouped to form a pedicellaria. In this case the spines are especially modified and encircle a pit in the plate; jaws usually 4 to 6. Rarely the 2 lateral furrow spines form part of the pedicellaria, there being then only the median left. On some plates simply the outermost 3 or 4 spines form a small pedicellaria. Almost all possible combinations occur.

Mouth plates narrow, as in the foregoing species. Spines irregular. There are 4 teeth at the inner end of the combined mouth plates; marginal spines small, forming an angular irregular series. Superficial spines forming an irregular crowded series along either side of the suture, the outer 1 or 2 of each series being enlarged.

Actinal intermediate plates few and armed with a fasciculate pedicellaria, with 4 to 6 slender jaws, and with several additional spinelets at the base.

Madreporic body hemispherical, small, about its own diameter distant from margin, and traversed by few course, irregular striae parallel to interradial line.

Type.—Cat. No. 30514, U.S.N.M.

Type-locality.—Station 5424, Sulu Sea, off Cagayan Island, Cagayanes Islands, 340 fathoms, coral sand, bottom temperature 50.4° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This form seems to be most closely allied to *A. tenellus*, which it resembles in having long rays, superomarginal spines on all but the distalmost superomarginals, and rather numerous subambulacral spines, of which 1 is enlarged. The general appearance of the two species is much alike. It differs from *tenellus* in having abundant abactinal and adambulacral pedicellariae, and pedicellariae on the superomarginal and inferomarginal plates; in having smaller paxillae, narrower superomarginal plates, less appressed, less flattened, and shorter superomarginal spinelets, and longer and more bristling lateral spines. In *tenellus* there are usually 3 of these, but in *pedicellaris* there are 4, except far along ray, and these 4 are nearer of a size than in *tenellus*. The presence of numerous pedicellariae on the adambulacrals alters the armature of those particular plates, but otherwise the arrangement of spines is much alike. The enlarged spine is relatively a little shorter in *pedicellaris*.

Pedicellaris differs from *griegi* in the presence of pedicellariae, which are entirely lacking in that species, and, in addition, in having no spine on the distal superomarginals, and in having a compressed median furrow spine.

From *eremicus*, *pedicellaris* differs in having longer rays, superomarginal spines and pedicellariae, only 3 furrow spines, an enlarged subambulacral, more numerous lateral spines and abundant inferomarginal pedicellariae. From *luzonicus* it differs in having superomarginal spines far along ray, superomarginal pedicellariae, more abundant abactinal pedicellariae, more numerous lateral spines, pedicellariae on the upper end of inferomarginals, more numerous superomarginal spines far along ray, superomarginal pedicellariae, spines. *Luzonicus*, *tenellus*, *pedicellaris*, and *griegi* are long-rayed forms; *eremicus* has much shorter rays while retaining the same general facies. It is possible that *tenellus*, *pedicellaris*, and *griegi* are forms of the same species, as they are similar in general appearance and in certain details, as for example in the arrangement of the adambulacral spines, and the presence of an enlarged subambulacral spine. *Griegi*, however, lacks pedicellariae, and several other differences have been listed above. It is not possible to solve the question with the available material.

Genus CTENOPLEURA Fisher.

Ctenopleura Fisher, 1913*a*, p. 608. Type, *C. astropectinides*.

Diagnosis.—Allied to *Astropecten*, but differing in having the gonads in a crowded series parallel to the marginal plates, and extending about a third the length of ray; inferomarginal plates with a lateral, oblique, compact comb of 3 to 5, usually 4, slender appressed spines, closely resembling the lateral comb of *Persephonaster*, and in addition 1 to 5 flattened, appressed spines on the actinal surface; adambulacral plates with usually 4 or 5 furrow spines (or, on the second and third plates, sometimes 6 or 7) instead of 3, the usual number in *Astropecten;* subambulacral spines small, none enlarged; often a fasciculate subambulacral pedicellaria is present; Polian vesicles 5. Other characters as in *Astropecten.*

Remarks.—This genus includes also *Astropecten ludwigi* de Loriol, of Japan, in which the gonads are arranged in series extending about a third the length of the ray. In *Astropecten* the gonads form a single tuft on each side of the interbrachial septum. *C. ludwigi* is rather closely related to *C. astropectinides.* Both have the general appearance of *Astropecten*, although the armature of the marginal plates is more like that of *Persephonaster.* A few species of *Astropecten* have 4 or 5 furrow spines proximally, but the usual number is 3. Many species of *Astropecten* have 6 Polian vesicles, but I am not certain that the character is of generic value.

The arrangement of the gonads in series will separate *Ctenopleura* from *Leptychaster*, *Bathybiaster*, *Psilaster*, *Blakiaster Astromesites*, *Ctenophoraster*, *Persephonaster*, *Tritonaster*, and *Patagiaster.* The very restricted development of the actinal intermediate plates will at once distinguish it from other Astropectinidae having serially arranged gonads, such as *Anthosticte*, *Tethyaster*, *Thrissacanthias*, *Dipsacaster*, and *Plutonaster*. The armature of the marginals will separate *Ctenopleura* from *Lonchotaster* and *Ripaster* in which the gonads are not described, while *Sideriaster* and *Moiraster* are distinguished by their large actinal interradial areas. Among the more nearly related genera some further differences may be enumerated. *Persephonaster* lacks the very angular astropectinoid adambulacral plates and has an angular series of mouth spines high in the furrow, while *Blakiaster* has pseudopaxillae and an odd interradial series of actinal intermediate plates. *Thrissacanthias* differs in having an enlarged subambulacral spine and a less angular furrow series.

CTENOPLEURA ASTROPECTINIDES Fisher.

Plate 16, figs. 1, 1*a*–*c*; plate 17, fig. 3; plate 18, fig. 2.

Ctenopleura astropectinides Fisher, 1915*a*, p. 608.
Astropecten astropectinides Döderlein, 1917, pp. 46, 62, 166.

Diagnosis.—Related to *C. ludwigi* (de Loriol),[1] but differing in having longer, narrower rays, shorter, stouter, superomarginal spines confined to marginal angle of ray, strongly 4-lobed abactinal plates on papular areas, and fewer actinal inferomarginal spines. R=129 mm., r=25 mm., R=5 r.; breadth of ray at base, 28 mm. Disk small, rays long, narrow, very gradually tapering to a bluntly pointed extremity; abactinal integument thin, paxillae, tall, spaced, bearing a compact upright group of 10 to 15 subequal, terete, slender, blunt spinelets varying from slightly shorter to slightly longer than the cylindrical, barrel-shaped, or compressed pedicels; superomarginals encroaching conspicuously upon abactinal area, the dorsal face tumid and about twice as wide as the lateral; marginal area of plates covered with short, slender, crowded spinelets, becoming coarse roundish granules on the summit of median transverse tumidity, the angle between lateral and dorsal facets bearing a transverse series of 2 to 4 short conical spinules; the first and the 3 or 4 last plates without spinules; inferomarginals proximally as wide as length of 3, slightly arched but actinal surface not at all strongly beveled; outer end armed with oblique comb of 4 slender, sometimes slightly curved, closely placed, appressed spines, the lowest or next to lowest the longest, and about 1.5 to 1.75 plates in length; spaced from these are proximally 2 spaced flattened sharp spines nearly as long as longest lateral spine; general surface covered with squamiform spinelets often spatulate in form; adambulacral plates with 4, proximally 5 or 6 (distally sometimes 3), rather long, flattened spines, the laterals subtruncate or round tipped; subambulacral spinelets proximally 12 to 16, subequal, slender, often flattened, and only about half as long as median furrow spine; most of the plates with a conspicuous fasciculate pedicellaria, made up of 6 or 8 of the subambulacral spines.

Description.—Paxillae fairly large, not crowded, but on the contrary rather spaced, especially on the disk, and arranged in slightly oblique transverse series, 5 or 6 of which correspond to the length of 2 superomarginals at base of ray. The paxillae are slightly smaller on the center of disk, and along the midradial line they are often very strongly compressed and larger than at either side. The pedicel is rather tall, subcylindrical, a trifle swollen at the middle, sometimes as mentioned above, more or less compressed, so as to be elliptical in cross-section. In the type the paxillae of the disk are about 3 mm. high, including the tuft of cylindrical spinelets, which vary from slightly shorter to slightly longer than the pedicel. In a specimen from station 5392 the pedicels on the disk, except near the extreme margin, are longer than the spinelets. The larger paxillae of the disk have 10 to 15 subequal, blunt, slender spinelets, usually standing erect in a compact group; when dried the spinelets become sharper.

---

[1] *Astropecten ludwigi* de Loriol, Mém. soc. phys. et d'hist. nat. Genève, vol. 33, pt. 2, No. 1, p. 21, pl. 2, fig. 4. (Tago, Japan.)

The plates of the papular area have a very characteristic form, which may be described as 4-lobed, the 2 lobes on the axis of the oblique transverse series being pointed, while the other 2 lobes are considerably broader and truncate. The plates do not touch, except sometimes near the margin, and most of them have a slight subconical or keellike elevation near or at the center. There are 6 papulae around each plate. Along a median radial area (about half as wide as either lateral papular area) and the center of disk the plates are irregularly subcircular to broadly elliptical and 1.5 to 2 times as broad as the lobed plates. This area is free from papulae, and the plates are spaced one-half to a little more than their own diameter. In *C. ludwigi* the plates of the papular area are only slightly or not at all lobed. The lobes are best marked on the outer part of the ray, the plates of the proximal portion being subcircular, with indications of 4 to 6 scallops on the margin.

Superomarginal plates, 48 or 49 in type, former much as in *A. ludwigi*, with a broad dorsal face passing by an abrupt rounded angle into the lateral face, which is about half the width of the dorsal. The exposed surface of the plate is decidedly convex along the median transverse line, this fact and the armature giving the species somewhat the appearance of a *Persephonaster*. The marginal area of the plate is covered with delicate, blunt, closely placed spinelets, which decrease in length toward the median transverse area, where the armature is in the form of coarse, rounded granules, which increase in size from the inner edge of the plate toward the lateral angle of the ray, these becoming more or less conical and sometimes squamiform around the base of 2 to 4 short, conical, stout spinules which form a transverse series or a group. These correspond to the superomarginal spines of *L. ludwigi*, but are more closely bunched on the margin of the ray. Sometimes a smaller, thick, granuliform, conical spinelet is found spaced from the others toward the inner margin of the plate, or a line of two or three such, especially on the second to fourth plates. The first plate lacks spines. On the outer third of the ray the granules cover most of the exposed surface, but as the middle of the ray is approached the granular area becomes narrower and the plates slightly more tumid. The last 4 or 5 plates seem to lack spines. A specimen from station 5392 has usually but 1 spine on the angle between the lateral and dorsal facets of the plate, except on the first 2 and last 4, where there are none; a few plates have 2, and the spinelets are not so granuliform on the central area as in type. Terminal plate wider than long, with a notch at the distal and proximal border, connected by a shallow sulcus.

Inferomarginals in general similar to those of *A. ludwigi*, the actinal surface proximally about as wide as length of 3 plates, the width gradually decreasing until distally it equals length of 2 plates. The rounded outer end of the plate bears, as in *ludwigi*, an oblique appressed vertical comb of 4 closely placed, slender, sharp, slightly flattened spines, the lowest or sometimes the next to lowest the longest and a little over one and a half plates in length, the uppermost about half to two-thirds as long. This comb is precisely similar to the lateral comb of *Persephonaster*. On the actinal surface of the plate and near the aboral margin, well spaced from the lateral comb, are proximally 2 flattened, appressed, sharp, well-spaced spines, varying from two-thirds to three-fourths the length of the longest lateral spine. On the outer half of the ray there is one only, about halfway between the inner end of the plate and the lower end of lateral comb. In one of the specimens from station 5392 there is but one actinal spine throughout the ray. The surface of the plate is covered with obovate spatulate squamules, usually round tipped, but becoming pointed at the base of the lateral comb.

Actinal intermediate plates extending to the fourth inferomarginal in type, there being 7 or 8 plates in a single row on each ray. The plates are covered with slender papilliform spinelets and 1 to 4 in each series has a central lanceolate appressed spinule. Occasionally the proximal plate bears a fasciculate spiniform pedicellaria.

Adambulacral armature very similar to that of *C. ludwigi*. Plates wider than long, placed obliquely, and with a salient furrow angle, bearing usually 4 strongly flattened furrow spines, the median tapering slightly and with its edge to the furrow, but the laterals truncate, and usually decidedly broader at the apex than base. The second to eighth plates are fewer, have 5 furrow spines, and in 1 specimen occasionally 6. Most of the plates of the type have 4 furrow spines, the laterals successively slightly shorter than the median. When there are 4 spines, 1 lateral is aboral to the apex spine and 2 adoral. On the outer third of the ray the adoral spine sometimes stands slightly back from the margin, leaving 3. In a specimen from station 5392 rather more of the proximal plates have 5 or 6 furrow spines than in the type. Subambulacral spinelets subequal, slender, proximally 12 to 16 (exceptionally a few more) and distally 8 or 10, varying slightly on either side of these extremes. They are about half as long as the median furrow spines, flattened and subtruncate proximally (especially on the inner part of plate), becoming terete and blunt distally. The spinelets are about the size of those of the actinal intermediate plates, and do not form regular series, although sometimes an indistinct arrangement in 2 longitudinal series is observable. As in *A. ludwigi*, there are no enlarged subambulacral spines, but on the aboral side of most of the plates is a conspicuous fasciculate pedicellaria, with 6 to 8 papilliform, subtruncate, blunt, or pointed jaws, forming a subcircular group surrounding a depression in the plate. On the outer part of the ray numerous plates lack the pedicellaria. Proximally some of the spinelets constituting the pedicellaria are broadened and grooved at the tip. The form of the spinelets is rather variable, however, some being tapered and bluntly pointed. In the 3 specimens of *C. ludwigi* which I have examined, the largest with R, 103 mm., the subambulacral pedicellariae are similar to those of *C. astropectinides*, except that the spinelets are a little more uniformly slender and pointed. The first plate is very strongly compressed and much wider than the others, bearing a closely placed double series of 30, or even more, slender, blunt spinelets, having the appearance of an immense pectinate pedicellaria. Usually only 1 is slightly enlarged on the furrow.

Combined mouth plates rather long and narrow, encroaching conspicuously upon actinostome and with a flaring marginal series of 7 or 8 slightly flattened round-tipped spines, which increase at first slightly, then rapidly, toward the inner heavy tooth, which is subterete, or slightly compressed. The surface of the plate is occupied by 2 crowded rows of about 18 spines, those near the inner half of the plate similar in form to the teeth though a trifle smaller. On the outer half of the plate the spines adjacent to median suture increase in length and assume a lanceolate form, while the spines of the other parallel series usually decrease markedly in length, so that at the outer end of the plate there is but 1 conspicuous series of spines. Sometimes these superficial spines are subspatulate. The lateral carries a series of small, spaced, slender spinelets, much smaller than those of the adjacent first adambulacral.

Madreporic body small, very convex, with irregular striae, and situated about midway between the center and margin of disk.

Color in alcohol, rather dark brown.

Anatomical notes.—Gonads in numerous closely crowded tufts attached to the genital stolon, and extending about one-third the length of the ray, close to the marginal plates. Each genital tube is either simple or with a few branches. Intestinal coecum spacious, saclike, in 3 unequal lobes, one of which being partly divided gives the appearance of 4. The form is very nearly the butterfly shape characteristic of *Persephonaster*. Anal aperture very small. Polian vesicles 5. Stomach spacious, filled with gastropods. Hepatic coeca slender, extending about half the length of ray. Superambulacral plates slender and rather long; lower end of ambulacral ossicles, with a broad flange distally, overlying part of a triangular adoral flange. Along the ambulacral ridge between each pair of plates is a sac-like depression resembling an opening into a cavity beneath, but apparently there is no connection with the underlying spaces. Blind tubes lead out from the coelom between the marginal plates, as in *Persephonaster*, at the point of junction of 4 plates.

Type.—Cat. No. 30515, U.S.N.M.

Type-locality.—Station 5520, 4.5 miles southwest of Point Tagolo Light, north coast of Mindanao, 102 fathoms, bottom temperature 61.3° F.; 1 specimen.

Distribution.—Between Samar and Masbate, south to the north coast of Mindanao, 102 to 135 fathoms, green mud and sand.

Specimens examined.—In addition to the type, 2 from station 5392, between Samar and Masbate, 135 fathoms, green mud, sand.

Remarks.—This species differs from *C. ludwigi* in having the rays longer, relatively narrower at the base, but tapering only very slightly until near the tip, so that they are of a different form. In *ludwigi* the rays taper evenly from the base to a pointed extremity, and R equals 4 r. or less in small specimens. In *C. astropectinides* R equals 5 to 5.5 r. *C. astropectinides* differs further in having shorter, stouter, superomarginal spines, on the marginal angle of the ray only, not across the dorsal facet of the plate, as in *ludwigi;* in having the abactinal plates of the papular areas strongly 4-lobed; in having proximally fewer actinal inferomarginal spines in addition to the lateral comb (3 to 5 in *ludwigi*); the actinal intermediate plates of *ludwigi* are less symmetrical, there being often in large specimens 1 out of place behind the mouth plates, simulating an odd actinal intermediate plate; the furrow spines are stouter and broader at the tip in *astropectinides*. Apparently the subambulacral pedicellariae are variable in occurrence in *ludwigi*. In the 3 specimens which I have examined they are abundant, but in a figure sent by Dr. S. Goto they are not shown except on the first plate.

Genus CTENOPHORASTER Fisher.

Ctenophoraster Fisher, 1906, p. 1014. Type, *C. hawaiiensis* Fisher.

CTENOPHORASTER DIPLOCTENIUS Fisher.

Plate 12, fig. 4; plate 16, figs. 2, 2*a–c*; plate 17, fig. 2; plate 18, fig. 1.

Ctenophoraster diploctenius Fisher, 1913*a*, p. 609.

Diagnosis.—Rays 5, R=105 mm., r=15 mm., R=7 r; breadth of ray at base 18 or 19 mm. Very closely resembling *C. hawaiiensis* in general appearance, but differing in having no median radial area of smaller irregularly arranged paxillae; in having the paxillae in regular curved transverse series on rays, with fewer paxillae to the series than in *hawaiiensis;* in having finer superomarginal spinelets and more numerous minute superomarginal fasciculate pedicellariae; in having slenderer and fewer inferomarginal spines, arranged in 2 oblique arcuate lateral series, and 1 transverse actinal series (not 3 and 2, respectively, as in *hawaiiensis*); in having tiny inferomarginal and numerous prominent actinal intermediate and subambulacral fasciculate pedicellariae; in having fewer subambulacral spines and prominent central spines to the actinal interradial plates.

Description.—The general form and proportions are like those of *hawaiiensis* and the abactinal surface has much the same appearance, except that the paxillae are more regularly and compactly arranged, and along the median line of the ray there is no well-defined stripe of small and irregularly arranged paxillae, as shown in plate 5, figure 2, Fisher, 1906. Instead the median radial paxillae are distinctly larger and fewer, and the paxillae of rays form slightly curved transverse rows, which continue uninterrupted across the radial area. At the base of the ray about 5 of these correspond to 2 superomarginals, and opposite the fourth superomarginal a transverse series contains about 16 paxillae, while in *hawaiiensis* there are about 22. The paxillae of disk are larger than those of the rays, and, as in *hawaiiensis*, are very close set. The general form of the paxillae is alike in the two species, but in *diploctenius* the spinelets are more delicate. A typical paxilla from the proximal portion of ray has 12 to 15 peripheral and 5 to 7 central, terete, round-tipped or subcapitate spinelets, while a large paxilla from the interradial regions of disk has 20 peripheral and 15 spaced central spinelets. Many of the paxillae bear a small central fasciculate pedicellaria with 4 or 5 practically unmodified, paxillar spinelets for jaws. They surround a hole in the tabulum. I have not been able to find them in *hawaiiensis*.

The abactinal plates, or bases of paxillae, as seen from the coelomic surface, are much longer than wide and very regularly arranged in transverse series. The shape, arrangement, and size are shown by the figure (pl. 16, fig. 2). Unlike *hawaiiensis*, *diploctenius* has over most of the ray a very regular, median radial series of elongate plates, accompanied by very small secondary plates, which externally have tabula and spinelets but are quite inconspicuous between the large paxillae and do not interrupt their regularity. Sometimes 2 consecutive radial plates are separated by a small secondary plate. Papulae are absent from this radial stripe and center of disk; elsewhere they occur very regularly in sixes about each plate.

Superomarginal plates, 53 to a ray, are oriented a little more obliquely than in *hawaiiensis* and are separated by deep fascioles, lined with fine spinelets. As in *hawaiiensis*, they form a rounded margin to the abactinal surface, encroach conspicuously upon abactinal area and are practically abactinal in position, except in the interbrachia, being much wider than high on the rays. The surface of the plate is covered with a nap of delicate, blunt spinelets, short on the exposed surface, becoming rather abruptly longer around the margins. They are more delicate than in *hawaiiensis* and are not enlarged at the outer end of the plate as in that species. (Fisher, 1906, pl. 3, fig. 1*a*.) A majority of the plates have a small fasciculate pedicellaria in the outer or lateral side and near the aboral margin, consisting of 3 to 6 small spinelets a little more tapered, but not longer than the surrounding spinelets. These pedicellariae are often hidden by the ends of the inferomarginal spines. Rarely a similar, though coarser, pedicellaria occurs in *C. hawaiiensis*, usually hidden by the ends of the inferomarginal spines. I overlooked these in the original description, as they are difficult to determine unless the specimen is dry.

The terminal plate is longer in proportion to width than in *hawaiiensis*.

Inferomarginals corresponding to the superomarginals and extending laterally slightly beyond them. They are short and wide, with the same type of armature as in *hawaiiensis*, but, generally speaking, the primary spines are more delicate and fewer and the thorny hooked tips less conspicuous. At the outer end of the plate in *hawaiiensis* there are 3 oblique, concentric, arcuate series of spines, the outer overlapping and covering the inner two (Fisher, 1906, pl. 3, figs. 1*a*, 1*c*). The innermost series has 3 to 5 spines (in *hawaiiensis*), the middle 6 to 8, and the outer series proximally 8 or 9, and distally 5 to 7. In *diploctenius* these numbers are: Inner series, not present; middle series, proximally 5, distally 3 or 4; outer series, proximally 5 to 7, distally 3 to 5. On the ventral surface of the plate, in *hawaiiensis*, there is a series of 5 to 8 stout, unequal, flattened spines continuing the outermost lateral series to the inner end of plate. These overlie 6 or more smaller and more delicate spinules, which represent a continuation of the innermost lateral series. In *diploctenius* the first of these series has 5 or 6 more delicate spines, proximally, and 2 or 3 distally, situated nearer the aboral margin than in *hawaiiensis*. The second series is not present. In front of—that is, adoral to—the outer row of lateral spines and its actinal continuation are numerous slender, flattened accessory spinules, tipped as the big spines and forming about the base of each spine a curved series of 4 or 5. The primary spines are all slenderer than in *hawaiiensis*, tapered, slightly curved, and with the characteristic thorny tip of *hawaiiensis*, only more delicate. The second or third lateral spine from the upper end is the longest, equaling in length 2 superomarginals. The underlying spines of the second lateral series are about as long, but more delicate. All are closely appressed to the side of the ray. The rest of the plate is covered with terete round-tipped spinelets similar to those of *hawaiiensis*. On the median line at the inner end of most of the inferomarginals of *hawaiiensis* is an enlarged spinule, which does not form a part of the transverse series. This is only rarely present in *diploctenius*. At about the middle of the actinal surface of a majority of the plates of *diploctenius* is a fascicular pedicellaria formed of several unmodified spinelets. I have not been able to find these in *hawaiiensis*. A portion of the description of the inferomarginals of *hawaiiensis* needs modification. It is stated (Fisher, 1906, p. 1015) that the actinal inferomarginal spines are blunt; they so appear in alcoholic specimens, but when dried the tips are thorny and as in plate 3, fig. 1*b* (ibidem). The curious hooked tips of the inferomarginal spines and spinules seem to be generic, but the membrane hides the hooks in the case of the actinal spines.

Adambulacral plates with fewer subambulacral spines than in *hawaiiensis* and with frequent fasciculate subambulacral pedicellariae. Furrow spines 3, blunt, long, slender, and compressed, the median the most. Subambulacral spines often in 2 longitudinal series of 3 each, with 1 to 3 shorter spines on the outer part of plate; or proximally the outer series, and sometimes also the inner, may have 4 spines. These are all tapering, slender, and blunt, those of inner row a little longer than furrow spines. The pedicellariae are of frequent occurrence and usually stand on the aboral inner corner of the plate. Each consists of about 5 tapering spines surrounding a pit in the plate. The aboral spine of the first actinal series sometimes stands on the furrow margin. This is regularly the case in *hawaiiensis* so that there appears to be 4 furrow spines, or 5 when the adoral member moves also to the margin. The actual number of furrow spines is only 3 in both species. First adambulacral plate compressed with about 15 spines in 2 transverse series.

Mouth plates densely covered with spines, the armature being similar to that of *hawaiiensis*. At inner end of plate are 4 heavy, blunt teeth forming a perpendicular comb (a part of the superficial series), which is continued to the outer end of the narrow plates, adjacent to median suture in about a dozen more, much slenderer, tapering, blunt spines, which become smaller as they approach the outer end of the plate. The actual marginal spines are small and form an angular series deep in the actinostome and between these and the superficial spines are 2 or 3 irregular series of intermediate spines.

Actinal intermediate plates extending in a single series to within 8 inferomarginal plates of the tip of ray and in a double series only as far as third. Back of the mouth plates and corresponding to them is a pair of intermediate plates, but between these and the margin is an odd interradial series of plates meeting the suture between the two first inferomarginals, as in *Blakiaster*, *Leptychaster*, and several other Astropectinidae. Exclusive of the plates immediately adjacent to the adambulacrals, each interradius has 17 intermediate plates. A majority of those adjacent to inferomarginals, both on rays and disk, bear a prominent fasciculate pedicellaria with 6 or more tapering, slender spiniform jaws, surrounding a deep central pit in the plate. These are surrounded by a number of divergent spinelets like the calyx of a flower, the whole forming an ornate, paxillalike structure. The other interradial plates bear a long slender central spine, surrounded by numerous shorter spinelets, resembling those of the general surface of inferomarginal plates. The intermediate plates all have fairly high tabula. A few of the intermediate plates of *hawaiiensis* have an inconspicuous pedicellaria with about 5 spiniform jaws on one side of tabulum, not a prominent central one involving the central spinelets of the plate, as in *diploctenius*.

Madreporic body small pentagonal, situated about twice its diameter from marginal plates and traversed by fine striae proceeding from the middle of the adcentral side.

Color in alcohol, dark brown; dried, sepia brown.

Type.—Cat. No. 30516, U.S.N.M.

Type-locality.—Station 5272, China Sea, vicinity of southern Luzon (lat. 14° N.; long. 120° 22′ 30″ E.), 118 fathoms, mud, shells, coral sand, bottom temperature 57.4° F.; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—The foregoing diagnosis and description has compared this form with the only other known species of the genus. It is interesting to note how closely the two forms have followed the same type of structure while differing in nearly every detail. At first glance the two seem to be the same, but such is undoubtedly not the case.

This species is another instance of the general similarity of the Hawaiian and East Indian faunas.

Genus PSILASTER Sladen.

Psilaster SLADEN, Narr. Chall. Exp., vol. 1, 1885, p. 611. Type, *Astropecten andromeda* Müller and Troschel.

Phidiaster KOEHLER, 1909, p. 28. Type, *Phidiaster agassizi* Koehler.

PSILASTER GOTOI Fisher.

Plate 16, figs. 3, 3*a–b*; plate 20, fig. 3; plate 21, fig. 1; plate 30, fig. 4; plate 35, fig. 3.

Psilaster gotoi FISHER, 1913*a*, p. 609.

Diagnosis.—Rays 5. R=58 mm., r=14 mm., R=4.1 r; breadth of ray at middle of interbrachium, 16 mm.: at third superomarginal, 13.5 mm.: height of combined marginal plates at middle of interbrachium, 7.5 mm.; at middle of fourth superomarginal, 6.5 mm. Disk fairly large, rays evenly tapered to a pointed extremity; interbrachia about 90°, rounded; superomarginals with a single row of prominent appressed spines extending nearly to tip of ray; inferomarginals with 2 series, one near the upper end of the plates and the other near the lower; adambulacral plates with 7 or 8 furrow spines proximally, and about 10 subambulacral spines in 2 series; mouth plates with horizontal fan of 4 prominent teeth. Differs from *Ps. agassizi* Koehler in having only 1 superomarginal series of spines, no well-defined central naked area on inferomarginals, and in having the superomarginals less conspicuous dorsally, and the inferomarginals practically confined to the sloping side wall of ray; furrow spines slightly more numerous.

Description.—Paxillae in slightly oblique transverse series, meeting a circular area (extending as far as madreporic body) of disk and a narrow radial area of the proximal half of ray where the plates are without regularity and closer together, owing to the absence there of papulae. The largest paxillae are on the outer part of this circular area and its stellate radial extensions, and they decrease in size toward the center of disk and margin and along the rays both toward margin and extremity. In center of disk is an epiproctal cone with minute paxillae, and a tiny anal aperture. At base of ray 6 transverse rows of paxillae correspond to 2 superomarginals, and between the second and third superomarginals about 21 paxillae can be counted across the ray to a corresponding point on the other side. The paxillae are flat-topped and the largest contain 15 to 20 cylindrical, very truncate spinelets, jammed together so that there is no clear distinction between a peripheral series and central group. Some of the peripheral spinelets are here and there notably slenderer, especially in a smaller specimen from station 5470, where the spinelets are not so crowded. A paxilla at base of ray has 8 to 18 spinelets according to whether it is near the margin or radius; on the outer fourth of ray, 5 to 8 spinelets.

Superomarginal plates, 33 or 34 to a ray, are massive and confined to side of disk in interbrachia, but the upper end soon widens, and the plates become lower, so that the lateral face about equals the dorsal, there being no sharp angle between the two for the plates form a rounded edge to the ray. The lateral face of the superomarginals is not vertical but sloping so that outside of the interbrachia the whole width of the plate can be seen when viewed from above. All except the last 5 to 10 plates bear a stout, flattened, sharp spine equal in length to 1.5 or 2 plates. In the interbrachia this is situated at the extreme upper end of the plate, and gradually recedes from the inner edge as the width of the dorsal face increases, keeping on the rounded angle between the latter and the lateral face. This spine is bent toward the end of the ray and usually appressed, except in interbrachia. The surface of the plate is covered with flat, large, squamiform granules with a polygonal or broadly leaf-shaped contour, the free edge turned upward on the lateral face of plate and distad on the dorsal, where the granules are largest. These are transformed into pulpy spatulate spinelets on the edge of the plate and finally in the narrow abrupt fasciolar grooves they become capillary. The base of the spine is surrounded by a small bare space, except at the base of the ray, but it is less extensive than in *Psilater agassizi.*

Terminal plate about as long as wide, with a notch on the proximal border, and with 3 stout sharp terminal spines, 1 dorsal and 2 lateral.

Inferomarginal plates confined to side wall of ray, except on outer fourth, forming a steeply sloping wall, their upper end projecting slightly laterally beyond the superomarginals. Except the first 3 plates, they are one-third to one-half higher than the superomarginals to which they correspond exactly. The first and sometimes the second plate bears at the lower end a single flattened sharp appressed spine pointed upward. The others, except the last 5 or 10 plates (which also have only the lower spine) have 2 such appressed spines, one near the upper and one near the lower end, and, proximally, near the median line but soon moving to the distal margin. These spines are very robust, the upper being about as long as the height of plate and the lower about three-fourths as large. The granules covering the plate are very flat and squamiform, broadly leafshaped and directed upward. On the median transverse area of the plate they are rather sparse, but there is no well-defined naked area. These squamiform papillae are invested with membrane like the superomarginal squamules but are not so pulpy as the actinal spinelets.

Actinal intermediate plates extend in a single series three-fourths the length of ray or to within 13 inferomarginals of the tip; in 2 series not quite half, and in 3 only to the fifth inferomarginal. There is no unpaired interradial series of plates except near the margin where 1 or 2 plates are interradial; these are met by paired series from the mouth plates or first adambulacrals. Or there may be an unpaired plate behind the combined mouth plates and another, widely separated, near the margin. The plates bear coordinated groups of 5 to 10 short pulpy spatulate or clavate papillae, borne on low tabula, and are separated into series by channels running from the interadambulacral sutures to the margin.

Adambulacral plates with strongly angular furrow margins, of which the aboral facet is slightly the larger. Furrow spines 7 or 8 proximally and 6 or 7 distally. They form a palmate series, the median the longest, and compressed with edge to furrow; the laterals with the surface to furrow. All are blunt with a slight membranous swelling at tip. The aboral member is often truncate. The subambulacrals are shorter, pulpy, clavate, or inverted-clavate, similar to the spinelets of the actinal intermediate plates. The calcareous spine is also club-shaped. They are usually arranged in 2 longitudinal series with about 5 spines in each. The first and second plates are much compressed, the first bears about 20 spines in 2 closely appressed transverse series.

Mouth plates much compressed and prominent actinally, the combined pair a little over twice as long as wide with a wide median suture of nearly uniform breadth throughout. Armature (1) at the inner angle of each plate a large oblong or oval leaflike tooth with a smaller one at the side sometimes nearly as long; (2) a marginal series of about 12 small strap-shaped truncate or round-tipped spines extending three-fourths the distance to outer end of plate, and appressed against a series of about 12 heavier, often clavate, but stubby spines, following the border of the suture. Except for the inner teeth each mouth plate resembles an enlarged first adambulacral.

Madreporic body small, a little nearer margin than center, and traversed by coarse striae.

Type.—Cat. No. 30517, U.S.N.M.

Type-locality.—Station 5468, Lagonoy Gulf, southeastern Luzon, 569 fathoms, green mud; one specimen.

Distribution.—Known only from Lagonoy Gulf, off southeastern Luzon, 560 to 569 fathoms.

Specimens examined.—Three; one from type-locality and one from each of the following stations:

Station 5460, Lagonoy Gulf, 565 fathoms, gray mud.

Station 5470, Lagonoy Gulf, 560 fathoms, mud.

Remarks.—This species is related to *Ps. agassizi* (Bay of Bengal, 888 to 930 fathoms), in so far as it comes within the restricted genus *Phidiaster* Koehler. It differs from *agassizi* in having a single series of superomarginal spines, the inner series of *agassizi* being absent. The superomarginals do not encroach so conspicuously upon the abactinal surface as in *agassizi*, and the inferomarginals are practically confined to the side wall of the ray and do not, as in *agassizi*, form a border to the actinal area. The inferomarginal spines are larger, the spinelets more squamiform, there is no well-defined central naked area on the inferomarginal plates, and the furrow spines are more numerous in *gotoi*.

This species is named for Dr. Seitaro Goto, of the Imperial University, Tokyo, author of a valuable monograph on the starfishes of Japan.

PSILASTER ROBUSTUS Fisher.

Plate 16, figs. 4, 4*a*; plate 20, fig. 1; plate 21, fig. 3; plate 30, fig. 3.

Psilaster robustus FISHER, 1913*a*, p. 610.

Diagnosis.—Rays 5. R=30 mm., r=9.5 mm., R=3.15 r.; breadth of ray at base, 12 mm.; height of combined marginal plates at middle of interbrachium, 6 mm.; disk large, rays stout and short, evenly tapered; superomarginal plates very massive, encroaching conspicuously upon paxillar area, than which they are wider at middle of ray; paxillae small, spaced; one series of superomarginal spines; one series of lateral inferomarginal spines and an incomplete second (ventral) series at base of ray; marginal plates covered with squamules and without naked areas; furrow spines 6 to 7. Differing from *Ps. gotoi* in having much more massive superomarginals, which encroach more upon paxillar area, smaller paxillae, thicker terminal plate, only 1 complete series of inferomarginal spines, shorter and more globose suboral spines, slightly shorter adambulacral spines, and a thicker, more robust form.

Description.—Paxillar area sunken below the level of the broad, tumid, superomarginal border, nearly plane except for a very prominent epiproctal cone. Paxillae rather small and spaced so that they lack the compact appearance of those of *gotoi*. Except for a stellate area, comprising center of disk, and the basal radial portion of ray, the paxillae are arranged in slightly oblique transverse series, which on the ray are scarcely interrupted at the radial line and therefore form complete slightly curved transverse rows, about 6 corresponding to 2 superomarginals at the base of ray. The general appearance of the paxillae is very similar to that of *gotoi*, the largest, in the interradial portions of disk, having about 12 coordinated close-set spinelets, a peripheral one being here and there smaller than the others. Smaller paxillae at base of ray have 5 to 10 spinelets.

Superomarginal plates, 21 to a ray, are broader than high except in the interbrachium, and the dorsal face of the plates is wider than long, forming a raised tumid border to abactinal area. The dorsal face of the plate passes into the lateral face very gradually, so that the edge of the ray is well rounded. Each plate, except the last 4 to 6, bears a prominent sharp, sometimes slightly flattened spine with a swollen base. On the first 2 plates the spine is near the inner edge of the plate, but on the third is about twice as far from the inner edge, and from the fourth on stands on the rounded border between the dorsal and lateral faces of the plate, and also gradually moves from the median transverse line to the aboral margin. The spines on the first 2 plates are really homologous with the inner (complete) series of *Ps. agassizi*, for near the inner edge of the third and sometimes the fourth plates of the type of *robustus* a similar spine occurs, making 2 for each of these plates, as regularly occurs throughout the ray in *agassizi*. This second spine is absent in the cotype. The plates are covered with spaced, circular, slightly squamiform and convex granules on the dorsal surface at base of ray, these becoming more and more squamiform toward the end of ray. On the lateral face of the plates all the granules are squamiform, with the edge upward.

Inferomarginals without distinct lateral and ventral faces, but forming a steeply sloping side to ray when viewed from below. The plates are slightly arched, so that the bevel is rounded. Beginning with the second or third plate is a row of sharp, prominent, flattened spines (slightly larger than superomarginal) extending nearly to tip of ray. The first 3 to 6 plates bear a similar smaller spine spaced from the lower end of the plate one-fifth to one-third width of plate. Exceptionally a proximal plate bears a small spine midway between the 2 series. The surface of plate is covered with spaced squamules, the edge directed upward, becoming closer and overlapping on the edge of plate. Beyond the proximal third of ray the inferomarginals exceed the superomarginals in height when viewed from the side.

Terminal plate stouter than in *gotoi*, nearly as long as wide, notched on the proximal border, and with 3 short tubercular spines on the end. It is sometimes ovoid in contour.

Actinal intermediate plates extending to ninth inferomarginal or a little over half the length of ray. There is exceptionally an unpaired plate behind the mouth plates, but no odd interradial series. The interradial areas are poorly developed, possibly owing to the small size of the specimen. The plates bear spaced groups of 2 to 6 clavate, pulpy papillae.

Adambulacral plates with an angular furrow margin and an armature consisting of 6 or 7 compressed, blunt furrow spines, the median with edge to furrow, and 8 or 10 much shorter, clavate and thick, pulpy, papilliform subambulacral spines, in 2 series, and uniform with the intermediate spines or spinelets. The armature is very similar to that of *gotoi*, but is a trifle shorter. The first adambulacral is much compressed with 18 to 20 spines in 2 closely appressed transverse series.

Mouth plates similar to those of *gotoi* in form and armature. There are 4 prominent flat truncate spatulate teeth at the inner angle of the combined plates, a wide median suture, and along the surface of each plate a double series of spines to the outer end, those of the inner or superficial series being subglobular to clavate, and the marginal spines being smaller and strap-shaped, closely appressed against the superficial spines, and of equal length. The marginal series extends to the outer end of plate, although the outer spines are widely spaced. In the foregoing species the marginal spines are considerably shorter than the superficial, which are less stubby, and the series does not occur on the outer fourth of the plate. On some plates of the present species it is lacking on the outer fourth, so that the character is of little value for specific distinctions.

Madreporic body small, a little over its own diameter from marginal plate, with a few coarse transverse (interradial) striae. A large paxilla stands at the adcentral side.

Type.—Cat. No. 30518, U.S.N.M.

Type-locality—Station 5632, south of Batjan Island, Molucca Islands (lat. 1° S.; long. 127° 50′ E.), 845 fathoms.

Distribution.—Known only from the type-locality.

Specimens examined.—Two; the type and specimen from station 5631, same locality, 809 fathoms, green mud.

Remarks.—While this species in a general way resembles *Ps. gotoi* from off Luzon, it differs very markedly in the structure of the marginal plates and their armature, and in having smaller, less close-set paxillae, and shorter actinal spines generally. The less extensive distribution of actinal intermediate plates of the present form may be due to its immaturity. This point can not be settled. That *robustus* is not the young of *gotoi* seems amply demonstrated by the presence of a specimen of the latter having R 27 mm. The differences hold good with the exception that in the small example of *gotoi* the lower series of inferomarginal spines extends only half the length of ray. Consequently in large specimens of *robustus* it may eventually be found that the lower inferomarginal series is much more extensive. The absence of a second series of superomarginal spines and of naked areas on the marginal plates will separate *robustus* from *agassizi*. The presence in *agassizi* of a well-marked ventral face to the inferomarginals is also an important difference.

The distribution of the inferomarginal spines together with the presence of enlarged teeth will separate this form from any species classified by Sladen under *Psilaster.*

Psilaster gotoi and *Ps. robustus*, as well as the following unnamed species belong to Koehler's genus *Phidiaster.* The characters of these species demonstrate that the structure of the superomarginals varies greatly. The superomarginals may be very narrow dorsally (*pectinatus*), or conspicuously broad (*agassizi*, *robustus*), or medium broad (*gotoi*). They may have 1 series of spines (*gotoi*, *robustus*, *pectinatus*), or 2 series (*agassizi*), or none (the following form). The size and armature does not seem to be of generic value. The inferomarginals vary also from having only 1 complete series to those having 2. In typical *Psilaster* the spines form usually transverse combs and are sometimes so placed as not to form also longitudinal series along the ray. But I have a specimen of *Psilaster florae*, a typical *Psilaster*, in which the spines form both transverse and longitudinal series, not all of the latter completed. In *Ps. pectinatus*, and exceptionally in *robustus*, the proximal plates may have 3 spines in a transverse series, or to put it differently, an intermediate longitudinal series is present. These 3 spines approach the condition of typical *Psilaster*, such as *Ps. florae.* The difference is one of number only. *Ps. pectinatus*, in regard to the disposition of the inferomarginal spines, presents an intermediate stage between *Ps. florae* and *Ps. agassizi* and *Ps. gotoi.* The presence of 2 closely appressed rows of spines on each mouth plate is common to typical *Psilaster* and *Phidiaster*, but in the latter the 4 inner teeth of the combined mouth plates are larger and are directed horizontally into the actinostome, a condition found also in *Ps. gracilis* (not otherwise like *Phidiaster*). If the inner teeth of *Psilaster florae* are bent downward so as to lie horizontally they are seen to be larger than the other mouth spines, although not quite so large as in *Phidiaster.* But *Ps. pectinatus*, otherwise like *Phidiaster*, has the teeth like *Psilaster.* Even here, therefore, the difference is rather one of degree, for the armature in arrangement is strikingly alike in the two groups. I have merged *Phidiaster* with *Psilaster* because the characters separating the genera are either variable or connected by intergrades. The extreme types, however, are easily enough separated, and *Phidiaster* will make a convenient subgenus whenever one is needed.

PSILASTER, species.

Station 5605, Gulf of Tomini, Celebes, 647 fathoms; 1 specimen.

This specimen, which has R 14 mm., is nearest *Ps. robustus*, but lacks entirely superomarginal spines and has less massive marginals and wider paxillar area. The terminal plate and inferomarginal plates and armature closely resemble those of *robustus.* Furrow spines, 5; subambulacral and intermediate spinelets granuliform; teeth very large.

This is perhaps a young *robustus*, but, owing to the absence of superomarginal spines and the smaller size of the plates, the specimen has been listed separately.

Genus ASTROMESITES Fisher.

Astromesites FISHER, 1913*a*, p. 611. Type, *A. compactus* Fisher.

Diagnosis.—Resembling *Persephonaster* and *Psilaster* in form, but differing from them and resembling *Leptychaster* and *Blakiaster* in the armature of the adambulacral and mouth plates, and especially in the possession of an odd interradial series of actinal intermediate plates. Differing from *Blakiaster* in having the abactinal plates compact and independent true paxillae, and in having well-developed marginal fascioles. Marginal plates massive, the inferomarginals with an appressed comb of slender spines; superomarginals unarmed; paxillae large, flat topped, crowded; actinal intermediate plates extending in a single series far along ray; adambulacral plates with an angular furrow margin bearing a divergent group of 5 to 7 spines and numerous subambulacrals, as in *Leptychaster;* mouth plates with extensive convex surface; 3 series of crowded suborals, graded in length from the straight, even furrow series of long spines, which are graduated toward 2 inner teeth; no sharp-angular furrow series as in *Perseptonaster;* disk small, rays stout, rather slender; actinal interradial areas small, the intermediate plates extending two-thirds the length of ray.

ASTROMESITES COMPACTUS Fisher.

Plate 19, fig. 1; plate 24, fig. 3; plate 25, fig. 2; plate 26, fig. 2; plate 31, fig. 4; plate 35, figs. 2, 2*a–d*.

Astromesites compactus FISHER, 1913*a*, p. 611.

Diagnosis.—R=78 mm., r=17 mm., R=4.6 r; breadth of ray at base, 20 mm. Disk small, rays narrow but stout, tapering regularly to a pointed but not attenuate extremity; sides of ray fairly high, rounded; marginal plates massive; interbrachial angle abruptly rounded; paxillae large, crowded, with numerous short, crowded, blunt spinelets; superomarginals unarmed; inferomarginals with lateral comb of 4 to 6 appressed spines; marginal fascioles rather deep, abrupt, and narrow; furrow series angular, of 5 to 7 spines; mouth plates with straight, numerous furrow series, and 3 series of suborals; interradial areas small, an odd interradial series of intermediate plates, and a single series far along ray; no pedicellariae.

Description.—Paxillar area compact, narrow, about 1.75 width of superomarginal plates, except at extremity of ray, where it is narrower. Paxillae large, crowded, nearly flat topped, arranged on the rays in slightly curved, transverse series, the regularity of which is interrupted proximally and distally along median radial lines. At base of ray 3 rows correspond to 1 superomarginal. The largest paxillae are on the disk about two-thirds distance from center to inner edge of marginals, and on the proximal fourth of ray on a broad radial area. The paxillae decrease in size very gradually toward center of disk, periphery of area, and end of ray. They have the appearance of being fairly uniform in size. The larger paxillae have 15 to 20 peripheral and 10 to 12 central, very short, almost granuliform, round tipped, minutely prickly spinelets. Owing to their crowded disposition the crowns of the paxillae vary from subcircular to polygonal.

The dorsal plates or bases of paxillae, are elliptical with 4 to 6 incipient lobes, so that the plates may appear somewhat 6-sided, though longer than wide. On the median radial area, where there are no papulae, the plates vary from elliptical and lozenge shape to broadly oval, and are close-set or proximally even slightly overlapping. On the papular areas of outer part of ray the plates are quite independent, but on disk and proximal portion of ray they touch by the incipient lobes. The plates are true paxillae, as the shaft is constricted in the middle—that is, flares at top and bottom. Papulae small, six about a plate, but absent from a median radial band, where the plates are elongate and crowded.

Marginal plates very massive. Superomarginals unarmed, encroaching conspicuously upon paxillar area, 34 in number, and forming a well-rounded border to abactinal surface. The plates are wider than long and there is a distinct abactinal and lateral face to each. The plates are separated by abrupt, rather deep, fascioles, narrower than the intervening ridges, and more like those of *Psilaster* than the more or less abortive V-shaped grooves of *Persephonaster* and *Blakiaster*. The exposed surface of this ridge is slightly tumid, especially on the outer part of ray and the summit of the ridge is near the distal margin, as in such species of *Persephonaster* as *euryactis* and *luzonicus*.

Exposed surface of plate covered with rounded, nearly flat granules, which gradually are transformed into slender spinelets of the fasciolar grooves. Terminal plate subovoid with 3 stubby spinelets on the end.

Inferomarginal plates opposite superomarginals, except sometimes on outer part of the ray, and with a rather broad rounded actinal surface passing imperceptibly into the lateral. They do not extend laterally beyond superomarginals. Rather deep fascioles separate the plates, which, on the tumid outer end, are armed with a vertical oblique comb of proximally 6, distally 4, appressed, slightly curved, sharp spines, of which the central 2 or 3 are the longest (at middle of ray, equaling the width of plate). Spaced from these, on the actinal surface of the first 10 plates, are 2 shorter, flattened, appressed spinules and on the succeeding 4 or 5 plates, 1 such spinule, situated near the distal margin. The general surface is covered with spinelets, short, truncate and granuliform on center, becoming much longer and slenderer on the sides, and very delicate in the furrows.

Actinal interradial areas small; intermediate plates small, arranged in series parallel to furrow, and also parallel to interradius. There is an odd interradial series of 5 intermediate plates, of which the innermost plate belongs to the second longitudinal series, since the proximalmost plates of the first longitudinal series are paired; that is, a pair of plates is opposite the outer end of the mouth plate and from these a single odd series proceeds interradially to the suture between the first inferomarginals, as in *Blakiaster*, *Leptychaster*, and other genera. Opposite the second adambulacral is a series parallel with the interradial which does not reach the inferomarginal. The next two extend from the third and fourth adambulacrals to the first inferomarginal. The number of plates in these interradial series decreases rapidly, so that opposite the third inferomarginal there are 2 series of 2 plates each. Thence a single longitudinal series of intermediate plates extends to two-thirds the length of ray (to twenty-first inferomarginal). The plates imbricate, are convex, and are covered by a paxilliform group of about 10 blunt, cylindrical clavate, central spinelets and as many slender, tapering peripheral ones. About a dozen plates in center of interradial area have each a slender, flat, sharp, appressed spinule, about as large as the actinal inferomarginal spinules.

Adambulacral plates oriented obliquely with a distinct angle projecting into furrow, and with an armature of the same type as that of *Leptychaster*. Furrow spines, slender, blunt, 5 to 7, of which that on the apex of margin is longest and most compressed, the rest decreasing regularly in length. Sometimes one or both lateral spines are crowded back from the furrow, leaving 5 or 6 instead of the maximum number of 7 furrow spines. Twelve or 14 shorter spines stand on the surface of the plate; about 3 of them are just back of the furrow series, and the remainder (more crowded and much shorter) are on outer part of plate. Sometimes the subambulacral spines arrange themselves in 3 longitudinal series, with 1 spine out of order back of the furrow series.

Mouth plates rather large and prominent actinally, and with an armature unlike that of *Persephonaster*, but more like that of *Leptychaster* and *Blakiaster*. There is no angular or fasciculate group of spines belonging to the marginal series between the base of the tooth and peristome. Marginal series, bordering furrow, rather long, even, fairly straight, composed of 11 spines of which the inner is flattened, oblong, blunt, 2.5 mm. long and directed upward, away from the mouth. The next is a little shorter and slenderer, while the succeeding 9 are of nearly uniform length, except the outermost 1 or 2 which are shorter, and are nearly as long as second tooth. They are narrow, strap-shaped, compressed and blunt, and are like the marginal spines of *Psilaster*, only longer, being appressed against the intermediate spines. This series is continued along the lateral sutural margin by a dozen smaller spinelets. The short stubby suboral spinelets are arranged in about 3 series on each plate, only that adjacent to median suture reaching the teeth. The spines on the inner end of this series are rather thick and blunt, and the whole suboral armature has the appearance of being crowded and graduated in length from the marginal series to the outer end of the plates where the spinelets are like those of the adjacent intermediate plates.

Madreporic body small, 2.5 its own diameter from marginal plates and crossed by rather coarse, irregular, transverse ridges and fine striae.

Tube feet pointed, without deposits; strong superambulacral plates; marginal coelomic pockets as in *Persephonaster;* gonads interradial.

Type.—Cat. No. 30519, U.S.N.M.

Type-locality.—Station 5289, Verde Island Passage, north of Mindoro (lat. 13° 41′ 50″ N.; long. 120° 58′ 30″ E.), 172 fathoms, broken shells, sand; 1 specimen.

Distribution.—Known only from off southern Luzon, 172 to 210 fathoms.

Specimens examined.—The type and 1 specimen from station 5296, China Sea, vicinity of southern Luzon, 210 fathoms, mud and sand.

Remarks.—*Astromesites* differs from *Persephonaster*, *Psilaster*, and *Bathybiaster* in having an odd interradial series of actinal intermediate plates. It differs further from *Persephonaster* in lacking the latter's characteristic angular marginal series (or fasciculate group) of oral spines, and in having an angular series of furrow spines, rather than a comb; from *Psilaster* in having broader mouth plates with numerous, crowded suboral spines in more than 1 series, an angular (not pectinate) furrow armature, and in lacking the thick, fleshy, actinal spinelets; from *Bathybiaster* in lacking lobes on the abactinal plates, fleshy actinal spinelets, and in having a different type of dental and marginal armature. *Astromesites* agrees with *Blakiaster* and *Leptychaster* in having the odd interradial series of actinal intermediate plates, and the same type of adambulacral armature. It differs from *Blakiaster*, however, as indicated in the diagnosis, and from *Leptychaster* in having armed inferomarginals of the type of *Psilaster* and *Persephonaster*. I should be inclined to rank *Astromesites* with *Blakiaster* were not the abactinal plates wholly different.

Genus PERSEPHONASTER Alcock.

Persephonaster Wood-Mason and Alcock, 1891, p. 430. Type, *P. croceus*.
Psilasteropsis Fisher, 1906, p. 1023. Type, *Ps. cingulata* Fisher.

KEY TO THE SPECIES OF PERSEPHONASTER HEREIN DESCRIBED.

a[1]. Marginal plates broad and conspicuous, the inferomarginals forming a wide bevel to actinal surface and bearing, on the outer tumid end, which projects laterally beyond superomarginals, a prominent comb of slender spines, covering, at least proximally, a second smaller parallel comb; superomarginals with a transverse series of appressed spines or spinules.
  b[1]. With several spines on the actinal surface of inferomarginals in addition to the lateral comb.
    c[1]. Rays broad and petaloid, abruptly narrowed to a very attenuate extremity; paxillar area broad; actinal intermediate plates extending fully two-thirds the length of ray, and larger; inferomarginal plates wider; superomarginal spines more prominent and numerous. *euryactis*, p. 112.
    c[2]. Rays narrower, evenly tapered; paxillar area narrower; actinal intermediate plates extending a little over one-half length of ray, and very small distally; inferomarginals narrower; superomarginal spinules inconspicuous.......*luzonicus*, p. 118.
  b[2]. Only the lateral comb of inferomarginal spines (except on first 3 or 4 plates).......*anchistus*, p. 117.
a[2]. Marginal plates massive, but not especially broad, the side of ray vertical; rays slender, more or less attenuate at tip; second lateral comb obsolete; superomarginals unarmed or with single spine, not a transverse series.
  b[1]. Superomarginals not conspicuously tumid and without special spine; no abactinal pedicellariae independent of paxillae.......*tenuis*, p. 121.
  b[2]. Superomarginals tumid, with a single spine, forming a straight series along ray; among the paxillae low plates bearing fasciculate pedicellariae independent of paxillae; no erect lateral spine above the inferomarginal comb.
    c[1]. Superomarginals very tumid with the transverse ridge situated at middle of plate, and evenly rounded from inner to outer edge; furrow spines 9; marginal fan of oral spines, 3 or 4, not prominent. *multicinctus*, p. 123.
    c[2]. Superomarginals less tumid and with the transverse ridge situated between center and distal margin of plate; an appreciable angle between the dorsal and lateral surfaces; inferomarginals broader, with less crowded, slenderer squamules; furrow spines 7 or 8; marginal fan of mouth spines 5 to 7, prominent.......*suluensis*, p. 125.
  b[3]. Marginals tumid, the inferomarginals being narrow and provided usually with an erect conical spine at upper end of plate, above the appressed, longer spines of the lateral comb; superomarginal spines in a single series along ray, passing from the inner edge of plate toward outer, after the fifth plate.......*monostoechus*, p. 134.

a^3. Marginal plates not massive, the superomarginals being small, squarish, and tumid, with a spine near center, and sometimes on the outer part of ray more than 1; the inferomarginals narrow but with a well-marked actinal face; rays depressed; paxillae rather spaced and delicate.

b^1. Rays broader; inferomarginals at base of ray about two-thirds to three-fourths as long as wide; no actinal series of spinules; more than 1 series of suboral spines, the mouth plates as a whole larger; marginal and subambulacral fasciculate pedicellariae; furrow spines 6 or 7. *oediplax*, p. 127.

b^2. Rays slenderer; inferomarginals narrower, the width not exceeding length, except on first 2 plates; 2 or 3 actinal inferomarginal spinules proximally, in addition to lateral comb; only 1 series of suboral spines; no marginal or adambulacral pedicellariae; furrow spines 5 or 6. *habrogenys*, p. 131.

PERSEPHONASTER EURYACTIS Fisher.

Plate 24, fig. 4; plate 25, fig. 4; plate 30, fig. 5; plate 35, figs. 1, 1*a*–*d*; plate 36, fig. 1.

Persephonaster euryactis FISHER, 1913*a*, p. 613.

Diagnosis.—R=92 mm., r=23 mm., R=4 r; breadth of ray at base, 24 to 26 mm. Rays depressed, broadly lanceolate, abruptly constricted near tip into a very attentuate, sharp extremity; interbrachium abruptly rounded-angular; superomarginal plates broader than long, and after the first half dozen, confined to abactinal surface; each tumid plate with a transverse, appressed comb of 3 to 7, flat, sharp spines; inferomarginals much broader than long, the outer tumid end bearing a comb of about 5 prominent, sharp spines; proximal plates with a second lateral comb of 3 to 5 spines covered by the first; curved furrow comb of 6 or 7 rather long spines; subambulacrals proximally about 6 in a single irregular series; actinal intermediate plates extending two-thirds length of ray.

Description.—Paxillae medium-sized, low, arranged in slightly oblique transverse series on rays, meeting a narrow radial area of irregularly arranged paxillae and a circular area on center of disk. Largest paxillae on disk are found interradially at about the middle of r, while on the rays the largest are in the lateral series near the radial line, although there is not much difference in size. At base of ray 6 or 7 transverse series correspond to 2 superomarginals. The spinelets usually stand erect in a compact flat-topped roundish group causing the paxillae to be spaced about one-half their diameter apart. Whenever the spinelets radiate the paxillae at once appear larger and closer together, even touching. Fifteen to 20 peripheral and 10 to 15 central slender, terete, blunt spinelets, longer than the stout pedicel compose the crown of the larger paxillae. Many of the paxillae bear a central fasciculate or pectinate pedicellaria consisting of 4 to 8 jaws, considerably stouter but not much longer than the regular spinelets. There are several giant paxillae on the disk, with upward of 60 or even more spinelets, and usually a central pedicellaria with 6 or 8 jaws. These may represent the primary apical plates.

Dorsal plates or bases of paxillae, broadly elliptical or subcircular, with 4 to 6 shallow notches on border. Papulae 6 about a plate, but absent from a narrow radial streak and center of disk.

Marginal plates massive. Superomarginals, 40 to a ray, are broad and tumid both as regards the cross and longitudinal axes, and are confined to the abactinal surface beyond the first half dozen plates. Proximally the plates are higher than wide, but they soon become much wider than high, and form a tumid raised border to the paxillar area. Inferomarginals extending laterally beyond the superomarginals. On the highest part of the plate, near the distal margin, is borne a transverse appressed comb of proximally 4 to 7, and distally 3 to 5, flat, sharp spines, the median or outer admedian usually the longest and about equaling the length of plate. On the proximal plates there is usually a second series of shorter spines just adorally to the first, which, farther along ray, are represented by several unequally enlarged, sharp, squamiform spinelets. The median transverse area of the plate is covered with closely appressed, acute, ovate squamules, which are rapidly transformed, toward the margins, into erect terete papilliform spinelets.

Inferomarginal plates much wider than long, and with an extensive sloping actinal face, forming a prominent, slightly arched, beveled border to the actinal surface, the outer end of the plate being rounded, tumid, and projecting beyond the superomarginals. The width of a plate about equals the length of 2. The armature consists of a lateral comb of proximally 5 and distally 4 or 5 long, slender, sharp, slightly curved spines on the outer end of the plate, the next to the lowest, or the lowest being the longest; or the 3 lowermost are subequal and equal to the length of 2.5 inferomarginal plates. Continuing this series along the distal margin toward the inner end of the plate are proximally 4 or 5 and distally 2 or 3 sharp, appressed, flattened, much shorter spines. Proximally this series reaches nearly to inner end of plate, but on the distal half of the ray the inner half of the plate is free from spines. In addition to these, the plates of the proximal half of the ray have a second comb of lateral spines parallel to and covered by the outer comb. This is a variable feature and is well developed only on the first 10 plates, but a remnant of the series in the form of a single spine continues nearly to the end of ray. There are usually 3 to 5 spines (considerably shorter than the other lateral spines) and several shorter spinules. The surface of the plate is covered with medium-sized, ovate or obovate imbricating, appressed squamules, with broad rounded ends. They are specialized into a series of short pointed spinules just adorally to the series of lateral spines.

Terminal plate small, rather oblong, with a small notch on the proximal end and a tuft of 5 or 6 small spines on the distal end. Surface covered with small lanceolate squamae.

Actinal interradial areas small, owing to the breadth of inferomarginals. Intermediate plates exending in a single series to twenty-second to twenty-fourth inferomarginal or two-thirds the length of ray, but beyond the middle they are very small. A second series of small plates reaches the sixth or seventh inferomarginal. In a transverse series between the first adambulacral and first inferomarginal are 5 or 6 small plates. The plates are spaced and bear paxilliform groups of 8 to 12 papilliform spinelets, and a few plates in the interradial region bear also a central tapering sharp spine 2 or 3 times as long as the spinelets.

Adambulacral plates slightly wider than long, with wide sutures between. Furrow margin angular, bearing a comb of 6 or 7 long slender compressed round- or squarish-tipped spines, the central 2 or 3 slightly the longest and with edge to furrow, the laterals with flat side thereto. The longest spines, at base of ray, equal 1.5 adambulacral plates in length or 1.3 inferomarginals, counting the intervening sutures in each case. Subambulacral spines proximally about 6, unequal, slender, tapering and swollen by membrane, shorter than the furrow spines and arranged in usually a single irregular series. Farther along ray the number increases to about 10 short, papilliform spinelets, in 2 series. On the outer part of ray they are no longer than the inferomarginal spinelets, but, of course, slenderer. The first plate is compressed, but still with a furrow comb of 6, and upward of 15 subambulacrals.

Mouth plates prominent actinally and with the typical *Persephonaster* type of armature. First there is a pair of stout, long, lanceolate or oblanceolate teeth; between the base of these and the peristome on either side is an oblique double row, or angular group, of 8 or 10 short, flattened, blunt spines, resembling a pectinate or fasciculate-pectinate pedicellaria. These are part of the furrow or marginal spines, and are continued along the side of the plate, adjacent to first tube foot, in a series (on the same level with the teeth) of 5 or 6 stouter, spatulate spines, forming a palmate group, but smaller in every way than the first adambulacral furrow series. On either side of the broad median suture is a series of about 12 to 15 broad, flat, leaf-like spines, the pair just back of the mouth spines being enlarged, and the outermost of the series smaller and more clavate. Between this series and the marginal, and extending far beyond the latter to the outer end of plate, is an intermediate series of smaller flattened papilliform round-tipped spinelets, also decreasing in size outward.

Madreporic body small at the middle of the minor radius, but nearer edge of paxillar area than center of disk. Striae small, radiating, irregular.

Type.—Cat. No. 30520, U.S.N.M.

Type-locality.—Station 5297, Verde Island Passage, off Batangas Bay, Luzon (lat. 13° 41′ 20″ N.; long. 120° 58′ E.), 198 fathoms, mud and sand; 2 specimens.

Distribution.—The typical form is known only from the type locality.

Remarks.—In the shape of the ray this species is like *P. coelochiles* Alcock (Andaman Sea, 230 to 250 fathoms), but lacks the stout, erect, superomarginal spine, and has the abactinal plates irregular along the radial line. The inferomarginal plates of *euryactis* are wider, and in *coelochiles* the second series of actinal intermediate plates extends far along the ray. The actinal accessory inferomarginal spines are lacking in *coelochiles*. *P. misakiensis* Goto is a closely related species.

PERSEPHONASTER EURYACTIS BREVISPINUS, new subspecies.

Plate 24, fig. 2; plate 25, fig. 3; plate 30, fig. 2; plate 36, figs. 2, 2*a*.

Diagnosis.—Differing from the type form in having fewer and shorter superomarginal spines, which are usually lacking on the first 5 or 6 plates, pedicellariae with slenderer jaws, and subambulacral spines in 2 rows throughout the ray. R=73 mm., r=19 mm. R=3.8+r.

Description.—The general appearance is closely similar to that of the type form, especially in respect to the size of disk and shape of ray. The paxillae are similar but the pedicellariae are not quite so numerous and the jaws are little if any stouter than the spinelets. Superomarginal plates with only a tuft of inconspicuous spinules, with 1 to 3 enlarged, but much shorter than the plate. Inferomarginals with the second lateral series of spines usually well developed and not reduced to a single spine until past the middle of ray, but this is rather variable, for a specimen from station 5550 (referable probably to a distinct forma of this race) has the second series less well developed than in *euryactis*. The actinal continuation of the primary lateral series consists of from 5 to 3, and finally 2 spinules, practically as in the type form. Furrow spines usually 7, and the subambulacrals in 2 series at the base of ray as well as on the outer part. Most of the actinal intermediate plates of the disk, adjacent to adambulacrals, bear a group of 6 or 8 tapering, blunt papilliform, or sharper, spinelets forming a fasciculate pedicellaria, more marked than in *euryactis*.

Anatomical notes.—More specimens of *brevispinus* being available than of the type form, it has been used for dissection.

Stomach eversible, with a single chamber, a circle of small glandlike out-pouchings of the dorsal surface representing perhaps the rudiment of the dorsal stomach. Hepatic coeca rather short, reaching about as far as seventh superomarginal plate; intestinal coeca conspicuous, and shaped somewhat like a butterfly, the intestine being where the body of the butterfly would be, and the 4 wings being represented by symmetrical divisions of the coecum. Anal aperture small. The greatest diameter of coecum equals about one-half r. A strong muscle proceeds downward from the base of the hepatic coecum and is attached to the first 3 ambulacral ossicles. Another proceeds from the fifth ambulacral ossicle and dividing into several branches is attached to the wall of the stomach, below the coeca. There are 10 of each of these. Gonads interradial, there being a single tuft depending from the dorsal integument on either side of the membranous interbrachial septum. Tube feet pointed, but with a small button; ampullae strongly double; Polian vesicles one in each interradius, except that of madreporic body, where there are 2. They are of an unusual form, having a narrow proximal neck and an enlarged distal kidney-shaped portion, around the edge of which are many simple or divided fingerlike coeca. Superambulacral plates well developed, absent from first 3 ambulacral plates.

Between the superomarginal and inferomarginal plates a series of tubelike diverticula of the coelom proceed horizontally toward the outside. The position of each diverticulum is where the transverse edges of 2 superomarginals and 2 inferomarginals meet, and the largest pore is the interradial one, while the others decrease in size, being quite small on the outer part of the ray. The outer end of the pore has a corresponding position with reference to the 4 plates. It ends blindly against the skin, but I have not been able to demonstrate a papula, although from the inside the passages have the appearance of papular pores. A natural supposition would be that they indicate where papulae once existed. In *Persephonaster oediplax* the pores are proximally still larger but no papulae can be discovered. The same pores exist in *Psilaster.*

Type.—Cat. No. 37002, U.S.N.M.

Type-locality.—Station 5289. Verde Island Passage, north coast of Mindoro (lat. 13° 41′ 50″ N.; long. 120° 58′ 30″ E.), 172 fathoms. shells, sand.

Distribution.—Balayan Bay, Luzon, and vicinity, and near Jolo Island, 172 to 258 fathoms. Apparently this variety lives on harder bottom than the type form.

Specimens examined.—Six; 3 from type-locality and 1 from each of the following stations:

Station 5290, near type-locality, 214 fathoms, lava, gravel.

Station 5365, Balayan Bay, Luzon, 214 fathoms.

Station 5550, vicinity of Jolo Island, 258 fathoms, fine sand, shells, bottom temperature 52.3° F.

PERSEPHONASTER ANCHISTUS Fisher.

Plate 26, fig. 3; plate 27, fig. 2; plate 36, figs. 4, 4*a–d*.

Persephonaster anchistus FISHER, 1913*a*, p. 614.

Diagnosis.—Similar to *P. euryactis*, but with slightly slenderer rays which taper evenly on the outer part to an attenuate extremity; actinal inferomarginal spines lacking except on the first few plates; superomarginal spines lacking on first 3 to 5 plates, and distally 1 to 3 in number; lateral comb of spines as in *euryactis*, but the second comb very poorly developed, usually represented by a single spine, behind one of the top spines of the first comb; paxillae arranged as in *euryactis* and of about the same size, but with slightly longer spinelets; abactinal pedicellariae numerous, with jaws only slightly, sometimes not any, thicker than the surrounding spinelets; subambulacral spines slightly more numerous than in *euryactis*, in 2 or 3 longitudinal series. R=143 mm., r=34 mm., R=4.2 r; breadth of ray at midinterbrachium, 34 mm.

Description.—The spinelets of paxillae usually stand erect, forming a flat-topped, compact 4-sided or rounded group. A rather large paxilla has 15 to 20 slender terete, blunt peripheral spinelets and 8 to 12 central ones, of which 3 or more are often slightly swollen and curved to form the jaws of a fasciculate pedicellaria. Abactinal plates elliptical, but with slightly undulating margin—not quite so obviously nicked or scalloped as in *euryactis*.

Superomarginal plates, 48 to a ray in the type, have the same proportions as in *euryactis*, and the type has usually 3 spines in a similar position except on the first 2 to 4 plates. Sometimes there are 4 or 5 spines. The central is the largest, and proximally is about as long as the plate, but distally is one and a half times. The specimen from station 5116 has usually only 1 spine not so long as its plate. The general covering of the plate is similar to that of *euryactis*.

Inferomarginals about the same proportions as in *euryactis*, but lacking the actinal continuation of the lateral comb except on the first 2 to 6 plates where actinal spines occur irregularly. This difference is the most striking one between *euryactis* and *anchistus*. The lateral comb has proximally 4 or 5 prominent appressed spines and distally 2 to 4. Underneath these there is often a single spine, the rudiment of the second lateral series. In the type the squamiform spinelets are much as in *euryactis*, though in the specimens from Balayan Bay they are much slenderer and pointed not truncate or round tipped. Similarly the superomarginal squamules of these specimens are slenderer.

Actinal intermediate plates extending two-thirds the length of ray in a single series; and in a double series as far as the eighth inferomarginal of type, and fifth of cotype (station 5116). The type seems to lack actinal intermediate pedicellariae, but a few are present in the cotype, next the proximal adambulacral plates.

Adambulacral armature similar to that of *euryactis*, but differing slightly in having more subambulacral spines. Proximally there are 8 or 10 in 2 series with the beginning of a third, and distally there are 12 to 14, in 3 irregular series, or without very definite serial arrangement. Furrow spines 6 or 7 in type, 7 or occasionally 8 in cotype, compressed, long, round-tipped or dully pointed. The mouth plates do not show any marked points of difference.

Color in life: "Salmon color" above, below very light (specimen from station 5111).

Type.—Cat. No. 30521, U.S.N.M.

Type-locality.—Station 5301, China Sea, vicinity of Hongkong (lat. 20° 37′ N.; long. 115° 43′ E.), 208 fathoms, gray mud, sand, bottom temperature 50.5° F.

Distribution.—Vicinity of Hongkong to southern Luzon, 200 to 236 fathoms.

Specimens examined.—The type, and 1 specimen from each of the following stations:

Station 5111, Balayan Bay, Luzon (13° 45′ 15″ N.; 120° 46′ 30″ E.), 236 fathoms.

Station 5116, same locality, 200 fathoms, bottom temperature 50.2° F.

Remarks.—*Persephonaster anchistus* is very close to *P. euryactis*, but the difference in the inferomarginal armature is constant. The specimens from Balayan Bay have the additional difference of possessing slender, pointed, inferomarginal spinelets.

Through lack of specimens it has not been possible to decide satisfactorily the status of this species. It is one of those exasperating forms which presents a close similarity to another species, yet has an obvious difference, the value of which it is not practicable to test rigorously on account of insufficient material.

PERSEPHONASTER LUZONICUS Fisher.

Plate 23, fig. 3; plate 24, fig. 1; plate 36, fig. 3, 3*a*–*b*.

Persephonaster luzonicus FISHER, 1913*a*, p. 614.

Diagnosis.—Resembling, in armature, *P. euryactis brevispinus*, but with narrower, evenly tapered rays, much narrower paxillar area, fairly large compact paxillae having slightly shorter spinelets, narrower inferomarginal plates, and a shorter series of actinal intermediate plates. R=78 mm., r=18 mm., R=4.3 r; breadth of ray at midinterbrachium, about 20 mm.

Description.—The most striking difference between this species and *P. euryactis brevispinus* is in the narrower rays, which, instead of being rather broad near the tip and then quickly narrowing to an attenuate extremity taper gradually from a narrower base. The superomarginals are of the same width in the two species, and as a consequence the paxillar area is much narrower in *luzonicus*, its width at one-third R from center being one and two-thirds to slightly less than twice the extreme width of a neighboring superomarginal, and at two-thirds R, about as wide as the superomarginal. In *euryactis* these members are respectively 2.5 or 2.75 and 1.75.

The paxillae are compact and the transverse series on the rays are interrupted along the median line. The paxillae are relatively a little larger than in *euryactis*. An average large paxilla from base of ray or interradius has 18 to 25 peripheral and about the same number of slightly shorter central spinelets, slender, terete bluntly pointed. Pedicellariae are very variable in occurrence. In the type they are lacking, or at least very scarce, but in an example from station 5329 they are very numerous, occupy the center of the tabulum and consist of 4 to 6 spiniform jaws a little shorter and stouter than the other spinelets. Abactinal plates broadly ellipitical to subcircular.

Superomarginals, 39 or 40. The lateral face is about half as high as width of dorsal, and on the well-rounded margin between the two, and near the distal edge of plate, are borne 1, 2, or 3 short, flattened, sharp, appressed spines. The plate is covered with appressed, pointed squamules, which become slender small spinelets around the borders of the plate, and especially in the shallow transverse channels between the plates. Terminal plate shorter and more ovoid than in *euryactis*.

Inferomarginal plates with a lateral comb of about 5 spines very similar to those of *euryactis*, and along the distal margin of the actinal surface, are proximally 3 or 4 appressed shorter spines, which are reduced distally to 2 and finally to 1. The second lateral series is variable but usually fairly well developed, with 3 to 5 spinules lying parallel to and under the upper half of the primary series. It extends typically farther along the ray than in *euryactis*. The plates are covered with flat round-tipped squamules, becoming longer at inner end of plate and resembling those of *euryactis*.

The actinal intermediate plates, owing to the narrowness of the ray, are very small beyond the proximal third or fourth, and although they extend to the twentieth or twenty-first inferomarginal, or a little over one-half the length of ray, they are practically rudiments attached to the inner edge of the inferomarginals. The interradial areas are small. The plates bear groups of rather slender spinelets, and in the interradial areas usually a central appressed spine, except on the plates adjacent to the adambulacrals, which bear pectinate or pectinate-fasciculate pedicellariae with 6 to 10 pointed jaws.

Adambulacral armature similar to that of *curyactis*, but furrow spines 7 or 8, the eighth being usually a shorter spine at the adoral end of the series. Proximally there are 8 or 9 subambulacral spines, slender, terete, blunt, much shorter than the furrow spines and in 2 longitudinal series; distally, 10 or 12 similar but relatively a little shorter spinules in 2 series, with often the beginning of a third, on the outer part of plate.

The mouth plates do not seem to differ constantly from those of *curyactis*.

Madreporic body similar to that of *curyactis*, situated at middle of r; striae numerous, rather fine, raidating from near center.

Anatomical notes.—The only internal features that show a tangible difference from those of *curyactis* are the Polian vesicles and intestinal coecum. The latter is of the same general form, but smaller, while the former has a larger distal portion with fewer coecal appendages. It is not unlikely that the form varies greatly with the degree of expansion of the bladderlike portion, and the size of course would vary similarly.

Type.—Cat. No. 30522, U.S.N.M.

Type-locality.—Station 5326, off northern Luzon (lat. 18° 32′ 35″ N.; long. 122° 01′ E.), 230 fathoms, mud; bottom temperature, 55.4° F.

Distribution.—Known only from off northern Luzon.

Specimens examined.—Seven; 3 from type-locality, and 4 from the following stations:

Station 5325, vicinity of type-locality, 224 fathoms, green mud, bottom temperature 53.2° F.; 1 specimen.

Station 5328, vicinity of type-locality, 150 fathoms, blue mud, bottom temperature 53.2° F.; 1 specimen.

Station 5329, vicinity of type-locality, 212 fathoms, blue mud, bottom temperature 51.4° F.; 2 specimens.

Remarks.—This species resembles both *P. curyactis brevispinus* and *P. tenuis*. It differs from *P. anchistus* in having the actinal inferomarginal spines, and in having narrower rays, narrower paxillar area, shorter paxillar spinelets, and a less extensive series of actinal intermediate plates on the ray. It is perhaps a little farther removed from *P. curyactis* than is *P. anchistus*, and it stands about midway between *curyactis* and *tenuis*. If *anchistus* and *luzonicus* are regarded as varieties of *curyactis*, then it will be difficult to consider *tenuis* more than a variety of *luzonicus*. The result would be the association of very dissimilar forms under one specific name, yet notwithstanding this they may each represent but a form of a highly polymorphic species. I know of no way to settle the question with the available material. The presence of gaps between the types has been my reason for regarding them as separate species.

PERSEPHONASTER TENUIS Fisher.

Plate 22, fig. 1; plate 23, fig. 2; plate 30, fig. 1; plate 37, figs. 1, 1*a–d*.

Persephonaster tenuis FISHER, 1913*a*, p. 615.

Diagnosis.—A slender-rayed species with blocklike conspicuous marginals, which are not markedly tumid as in the "cingulate" species such as *multicinctus*, *cingulatus*, and *roulei;* superomarginals with slightly wider dorsal than lateral face; lateral face of ray perpendicular, the upper and lower margin evenly and abruptly rounded; superomarginal plates without conspicuous spines; inferomarginals narrow, with lateral comb of, proximally, 5 rather short slender appressed spines, and 1 actinal spinule on the proximal plates only; furrow spines 7 or 8; subambulacrals 4 to 7 proximally, distally 8 to 10; a few fasciculate adambulacral pedicellariae. R=81 mm., r=18 mm., R=4.5 r; breadth of ray at base, 20 mm., at tenth superomarginal, about 11 mm.

Description.—Paxillar area rather narrow, but superomarginals narrower than in *luzonicus*, so that the area appears wider than in that species (although of about the same width). Paxillae arranged as in foregoing species and of nearly the same size and shape, being low tabulate but with slightly larger and fewer spinelets. A large paxilla from interradial area has about 15 to 18 peripheral and 8 to 12 central, terete, slender, blunt, or bluntly pointed spinelets, a little longer than the low tabulum. Many paxillae have an inconspicuous central fasciculate or fasciculate-pectinate pedicellaria with 4 to 6 spiniform jaws.

Superomarginals 37, much less tumid than in *multicinctus*, and about as tumid as in *luzonicus;* dorsal face slightly wider than the lateral, the angle between the two evenly rounded. The transverse fascioles between the plates are shallow and more abrupt than in *multicinctus*, the tumidity being near the aboral margin and not in the middle. Plates covered with very small, slender appressed squamiform spinelets, which beyond the middle of ray become enlarged into 1 to 3 short appressed inconspicuous spinules. Terminal plate slender, subcylindrical, longer than wide, with a conspicuous terminal spine and a much smaller spinelet on either side.

Inferomarginals narrower than in *luzonicus;* lateral face a little narrower than that of superomarginals and bearing a slightly oblique comb of proximally 5, distally 3 or 4, slender, appressed, sharp spines, the lowest but one usually the longest, and the lowermost next longest, the former slightly exceeding the plate in length. Underneath the upper members of this series, on the first few plates, a rudiment of the second comb is usually present and the first half dozen plates have a small solitary spinule near the middle of the actinal surface and distal margin of the plate—a rudiment of the actinal spines of *luzonicus* and *euryactis*. The actinal surface of the plates is much narrower than in *luzonicus* and a trifle wider than in *multicinctus*. The general covering of the plates consists of appressed, uncrowded, squamules round tipped at base of ray, becoming pointed distally.

Actinal intermediate plates small on the ray, a single series extending to the tenth inferomarginal or less than one-third the length of ray measured along side. For the length of 5 inferomarginals beyond this point the series is continued by a variable number of minute rudiments not visible unless the inner end of the inferomarginals is cleaned of spinelets. In a transverse series between the first adambulacral and inferomarginal are 5 small plates. The plates bear spaced groups of 4 to 8 lanceolate, papilliform, blunt, spinelets, the central one being sometimes enlarged. Several plates adjacent to the adambulacrals bear a pectinate or fasciculate-pectinate pedicellaria with 6 or 8 teeth.

Adambulacral armature of the type of the foregoing species. Furrow comb of 7 or 8 spines, the laterals the shortest, so that the end of the fan has a curved contour. Proximal plates with 4 to 7 subambulacral spines in a single series, with a spine or 2 out of line, and distally 8 or 10 in 2 or 3 series, all much shorter than the furrow spines. On a few plates some of the spines form a simple fasciculate pedicellaria, and are not appreciably modified. The first and second plates are conspicuously compressed, the first with a double pectinate transverse series of 14 to 16 spines.

Mouth plates and armature similar to forgoing species. The marginal spines below the base of the large inner tooth are short conical and bluntly pointed and form a fascicular group of 6 or 7 resembling a pedicellaria. The portion of the series on a level with the teeth consists of 3 or 4 small spines; the inner tooth is thick, slightly tapered and blunt. The superficial spines are in 2 series on each plate, the inner next to suture reaching the outer end of plate and consisting of rather thick, blunt, lanceolate spinules; the intermediate spines are irregularly placed, much smaller, and do not attain the outer end of plate.

Madreporic body medium-sized, the adcentral edge being at the middle of r.

Type.—Cat. No. 30523, U.S.N.M.

Type-locality.—Station 5301, China Sea, vicinity of Hongkong (lat. 20° 37′ N.; long. 115° 43′ E.), 208 fathoms, gray mud, sand, bottom temperature 50.5° F.; 1 specimen.

Distribution.—China Sea, vicinity of Hongkong.

Specimens examined.—The type, and 1 specimen from station 5302, near type-locality 38 fathoms, soft gray mud (probable error in locality).

Remarks.—This species differs from *luzonicus* in having still narrower rays; superomarginals which encroach less upon the paxillar area, and which have proportionately higher lateral faces; more delicate superomarginal spinelets; practically no specialized spines, except a very small one on the distal plates; actinally narrower inferomarginal plates with only 1 small actinal spine on a few proximal plates; shorter lateral spines; more restricted actinal intermediate plates; adambulacral pedicellariae; proximally fewer subambulacral spines; longer and slenderer terminal plate. The narrow rays, narrow inferomarginals and superomarginals, shorter lateral spines, and the short series of actinal intermediate plates are among the differences separating *tenuis* from *euryactis* and *anchistus*. From *multicinctus*, *tenuis* differs in not having such tumid marginal plates, in having shorter lateral spines, no superomarginal spine, fewer furrow spines, smaller paxillae, and a more pronounced angle between the actinal and lateral faces of the inferomarginal plates. In *multicinctus* the actinal surface of the plates is beveled and the outer end quite tumid. An additional difference is the absence in *tenuis* (and in the other preceding species) of the specialized abactinal pedicellariae. These occupy low plates independent of the paxillae.

Psilaster gracilis Sladen seems to be an aberrant *Persephonaster*, with much reduced marginals. It differs from *Psilaster* and agrees with *Persephonaster* in having at the base of each tooth a group of spinelets—a part of the marginal series—directed across the mouth of the furrow. *P. gracilis* has even more attenuate rays than *P. tenuis*, and has much smaller marginal plates. The inferomarginals are narrow and rounded, without a prominent actinal face, and the mouth plates are smaller, with a smaller tuft of spinelets at the mouth of furrow.

PERSEPHONASTER MULTICINCTUS Fisher.

Plate 25, fig. 1; plate 26, fig. 1; plate 27, fig. 1; plate 37, figs. 2, 2*a*–*c*.

Persephonaster multicinctus Fisher, 1913*a*, p. 616.

Diagnosis.—Of the type of *P. cingulatus* Fisher and related to *P. roulei* Koehler, from which it differs in having abactinal and marginal pedicellariae; fewer paxillar spinelets; a slender appressed, central superomarginal spine, forming a single longitudinal series along ray (not 2 conical robust ones, forming 2 parallel series along ray); more numerous furrow spines. Disk larger than in either *cingulatus* or *roulei.* R=110+mm. (tip of ray broken), r=24 mm., R=4.6+r; breadth of ray at base 28 mm. Interbrachia open; rays tapering very gradually; height of ray at base less in proportion to width than in *cingulatus* or *patagiatus.*

Description.—Marginal plates massive, tumid, the superior series encroaching markedly upon paxillar area; the latter narrow on rays, beyond the middle being about as wide as a corresponding superomarginal. Paxillae small, with a low pedicel surmounted by a flat-topped group of terete, blunt spinelets as long, or slightly longer than height of tabulum. Largest paxillae, at base of rays and on disk at middle of r, with about a dozen peripheral and 5 to 7 central spinelets. Far along ray the spinelets are much higher than tabulum and as few as 2 or 3, more often 5 to 8 in a coordinate group. Scattered over the paxillar area are fairly numerous plates without a perceptible tabulum and with 2 to 10 tapering, pointed spinelets, markedly stouter than those of the regular paxillae, and forming fasciculate or fasciculate-pectinate pedicellariae. Plates intermediate between these and the normal paxillae are observable. Sometimes the spines form two opposed rows, sometimes are grouped in a circle.

Superomarginals over 40, shaped as in *P. cingulatus*, the median transverse line being covered with scalelike granules, the slopes on either side with tiny terete spinelets. Near middle of plate are one or 2 slender appressed, sharp, flattened spinules not as long as the plate (absent from 6 or 7 interbrachial plates). Each plate also has several inconspicuous fasciculate pedicellariae, modified from both the slender and the scalelike spinelets, and occurring on both upper and lateral faces of plate.

Inferomarginals corresponding to superomarginals in number and position, tumid and encroaching upon actinal area about as much as in *cingulatus.* Proximally the plates bear a lateral oblique comb of 3 or 4 slender, flat, sharp, appressed spines, about the same length as in *cingulatus* (but fewer). The general covering of the plates consists of squamiform granules, or spinelets, becoming more spiniform on the margins. There is also a fasciculate spiniform pedicellaria near the upper margin of most of the plates.

Actinal interradial areas small; the first series of intermediate plates extending to the eighteenth inferomarginal, or half the length of ray, the outer plates being small and rudimentary; the second series to the sixth plate; the third series to the third plate, while in the first interradial series between mouth and first inferomarginal plates

7 plates occur, and in the next 2, also meeting the first inferomarginal, are 6 and 5 plates, respectively. The covering of the intermediate plates resembles that of *cingulatus*, but the spinelets are even more numerous and each interradial triangle contains about 10 or 12 slender elongate spines and a very few fasciculate pedicellariae, with 4 or 5 spiniform jaws on the plates adjacent to adambulacrals.

Adambulacral plates with a curved furrow margin, 9 furrow and 2 longitudinal series of slender, membrane-covered, rather fleshy subambulacral spines, about 5 in the inner series and 4 to 7 slightly shorter ones in the second. The tips of the furrow comb form a straight or only slightly curved contour, and the armature is of the type of *cingulatus*. The subambulacral spines have a conspicuous lateral flange of skin, and look as if webbed for more than half their length. They are not, however. The appearance is due to the juxtaposed edges of the vanes. On the first to the third plates a few actinal spinelets may be coordinated into a conical pedicellaria.

Mouth plates with a very large, broadly lanceolate, inner tooth. The true furrow series forms a very acute angle on the level of the base of this spine in such a way that a horizontal or oblique double series of altogether six or seven spinelets projects across mouth of furrow, near the peristome. Ten or more additional spinelets continue this series from the base of the tooth along the true margin of plate to the outer end, and considerably above (as viewed actinally) the double angular series referred to above. There are numerous suboral spinules in 2 additional (interradial) series much as in *cingulatus*.

Madreporic body small, very convex, on the marginal side of the center of r. Striae like those of *cingulatus*.

Type.—Cat. No. 30524, U.S.N.M.

Type-locality.—Station 5648, Buton Strait, Celebes (lat. 5° 35′ S.; long. 122° 20′ E.), 559 fathoms, green mud, bottom temperature 39.2° F.

Remarks.—This species differs from *P. cingulatus* in having much smaller paxillae, abactinal and numerous marginal fasciculate or fasciculate-pectinate pedicellariae, 1 or 2 slender appressed superomarginal spines, fewer inferomarginal spines, smaller inferomarginal squamiform granules or spinelets; much heavier teeth; larger disk; and the combined marginal plates are lower in proportion to width of ray.

PERSEPHONASTER SULUENSIS Fisher.

Plate 22, fig. 2; plate 23, fig. 1; plate 38, figs. 1, 1*a*–*c*.

Persephonaster suluensis FISHER, 1913*a*, p. 617.

Diagnosis.—Near *P. multicinctus*. Differs in having the superomarginal plate with the transverse ridge between the center and aboral margin of the plate, not in the center; inferomarginals appreciably broader, with less crowded squamules; furrow spines 7 or 8; marginal fan of mouth spines prominent, 5 to 7, nearly as long as first adambulacral furrow spines. R=61 mm., r=14 mm., R=4.3 r; breadth of ray at base, about 16 mm.

Description.—The difference in the appearance of the abactinal surface of *suluensis* and *multicinctus* is chiefly due to the more evident tumidity of the latter's superomarginals, and the position of the summit of this on the median transverse line of the plate—not near the distal margin. The superomarginals of *suluensis* are not evenly rounded from the inner to the lower or outer margin but have a fairly plane and horizontal dorsal facet at nearly right angles to the lateral, the margin of the ray being abruptly rounded. In *suluensis* the spinelets of the exposed surface are lanceolate squamules, while in *multicinctus* a narrow transverse band is clad with roundish squamiform granules abruptly larger than the other spinelets. In *suluensis* the inferomarginals extend laterally slightly beyond the superomarginals, and the lateral comb consists of proximally 4 and distally 3 sharp, slender appressed spines. The first 2 or 3 plates may have a rudiment of the second comb, covered by the upper spines. This is lacking in *multicinctus*, and the inferomarginals do not extend laterally beyond superomarginals. The plates are wider and the actinal surface more nearly plane than in *multicinctus*. On the first 8 plates a delicate spinule, spaced from the lateral comb stands on the adoral margin, as in *tenuis*. (In *multicinctus* this spine is present but larger, and a second may be present on the first 3 or 4 plates.) The squamules covering the plates are lanceolate to oval, smaller than in *multicinctus*, and slightly spaced, not crowded and overlapping.

The abactinal paxillae are about the same size as in *multicinctus*. A large paxilla has 15 to 18 peripheral and 8 to 10 central, delicate, terete, spinelets, shorter than the low pedicels. The pedicellariae are distinctly larger than neighboring paxillae and have 4 to 8 pointed jaws, either forming 2 opposing rows, or a circle. There are a number of low paxillae, with spinelets, in addition to the pedicellariae, forming a transition between normal paxillae and the low pedicellarian plate. In proportion to the neighboring plates the pedicellariae of *suluensis* are larger than in *multicinctus*, in which the pedicellariae are equal to the paxillae, or sometimes a trifle smaller or a trifle larger, but not conspicuously larger.

Actinal intermediate plates extending nearly two-thirds length of ray, but the outer ones are minute and rudimentary. In *multicinctus* they extend half the length of ray. The plates bear groups of rather numerous, slender, spinelets, with one enlarged, in the interradial region. Most of the proximal plates adjacent to the adambulacrals bear fasciculate pedicellariae. These are present in *multicinctus*, but are much smaller, as they never occupy the whole plate. The enlarged spinules are larger in *multicinctus*.

Mouth plates with a conspicuous lateral fan of 5 to 7 marginal spines, nearly as long as the first adambulacral furrow spines, and the usual oblique double series of about 10 spinelets between the base of tooth and peristome. The superficial spines are in 2 series on each plate, and the marginal series is carried to the outer end of plate by several additional small spinelets. The teeth are much as in several other species, rather long, stout, slightly swollen, with a blunt tip. In *multicinctus* the lateral marginal comb is much less conspicuous.

Type.—Cat. No. 30525, U.S.N.M.

Type-locality.—Station 5424, Sulu Sea, near Cagayanes Islands, 340 fathoms, coral sand, bottom temperature 50.4° F.; 1 specimen.

Remarks.—This species is similar, also, to *P. tenuis*, but differs in the presence of the conspicuous though small superomarginal spine, the wider inferomarginals, the much less compressed first adambulacral plates, the longer and more numerous marginal mouth spines, the proximal subambulacrals in 2 series, and the specialized abactinal pedicellariae. From *suluensis*, *luzonicus* differs in having conspicuously wider marginal plates, no specialized abactinal paxillae, and in lacking all but rudiments of the actinal inferomarginal spines and the second lateral comb. *P. anchistus* which, like *suluensis*, lacks the actinal inferomarginal spines, differs in having wider rays, more depressed superomarginals, no specialized abactinal paxillae, usually more numerous superomarginal spines, longer paxillar spinelets, a more extensive series of actinal intermediate plates. The oral and adambulacral armature is much alike in both species, but the distinctly broader rays and more depressed marginals of *anchistus* will serve to separate it at once. It is probable that *suluensis* is rather closely related to *anchistus*, as well as to *multicinctus*, although the curious pedicellariae are lacking in *anchistus*, the less specialized paxillar type only being present.

PERSEPHONASTER OEDIPLAX Fisher.

Plate 22, figs. 3, 4; plate 23, fig. 4; plate 31, figs. 2, 3; plate 38, figs. 2, 2*a*–*d*.

Persephonaster oediplax FISHER, 1913*a*, p. 617.

Diagnosis.—Marginal plates small and tumid, the superomarginals bearing a central or subcentral small spine, or distally 2; the inferomarginals extending laterally slightly beyond superomarginals, the tumid outer end bearing a narrow comb of 3 or 2 slender appressed spines; no actinal inferomarginal spines; superomarginal, inferomarginal, abactinal, actinal intermediate, and subambulacral fasciculate pedicellariae; furrow spines 6 or 7, rather long, slender, compressed; subambulacral spines 8 to 12, slender and short. Rays long, of medium width, thin and with an attenuate extremity. R=95 mm., r=20 mm., R=4.75 r; breadth of ray at base, 22 mm.; breadth at two-thirds r, 8 mm.

Description.—Rays, slightly variable in width, but of medium breadth, appressed, the marginal plates forming a thin edge. The superomarginals do not encroach much upon paxillar area and in consequence the latter is broad. Abactinal integument rather thin and flexible, and the paxillae in consequence of the upright position of their spinelets, appear spaced. Arrangement of paxillae typical of *Persephonaster*. Paxillae largest on interradial regions and adjacent portions of the base of ray where they are of medium size, and consist of 15 to 20 terete pointed spinelets longer than the rather low pedicel. In the center of the disk the paxillae are very slender, with 8 or 10 spinelets, the pedicel being longer, shorter, or equal to them in length. Many paxillae have a fasciculate pedicellaria of slightly thickened spinelets.

Abactinal plates irregularly elliptical on papular areas and more roundish on median radial line. Plates of the transverse series touch each other or even overlap slightly but consecutive series are spaced. Many of the plates of the outer half of ray are shaped like an open fan, and the transverse rows are little or not at all interrupted on the radial line. Papulae absent from small area at center of disk and along a narrow radial band.

Superomarginals, 40 in number, are quite small and form a narrow border to paxillar area, the inferomarginals extending laterally beyond them and forming a scalloped margin to the ray. In the interbrachial angle the plates are wider than long, then they become square, and beyond the first third of the ray the length gradually increases over the width, as the plates become smaller and smaller. The plates are tumid, the apex of the tumidity bearing a short, conical spine and moving from the middle of the plate (at base of ray) to a little distad of the middle. On the outer fourth of the ray the plates are not tumid, and have 2 or 3 spines in a transverse series. The plates are covered with a fine nap of very delicate spinelets, becoming appressed around the base of the spine and most of them have 1 or 2 small fasciculate pedicellariae near the inner edge. Terminal plate very slender, subcylindrical, round-tipped, with a stout terminal spine and 2 or 3 smaller ones on either side.

Inferomarginals on first third of ray equal in width to 1.5 the length; at middle of ray the width only slightly exceeds the length. From this point the ray becomes rapidly very attenuate, and the plates are longer than wide. Most of the width of plate is occupied by the actinal face, the lateral facet being low, not half as wide as the actinal. This outer end is tumid and bears a short oblique comb of 3, distally often 2, slender, tapering, sharp, appressed spines, the middle, or the 2 lower the longest, or sometimes the lowest. At the first third of the ray the longest spine equals 2 or 2½ plates, and the comb often is largely abactinal in position, the spines resting on or against the superomarginals. The first 3 or 4 plates may have 4 spines in the comb, with an additional actinal spinule, and 1 or 2 spinules out of place in front of the comb. Plates covered with spaced, rather slender, flattened, appressed spinelets, sometimes broader and more scalelike. The first few plates usually have 1 or 2 fasciculate pedicellariae near the inner edge consisting of about 6 stubby spinelets and another at the outer end, near the base of the uppermost lateral spine, this upper pedicellaria persisting to the outer part of the ray.

Actinal interradial areas small; intermediate plates extending to twenty-first inferomarginal or about two-thirds length of ray. They are very small and well spaced beyond the first fourth of the ray. Plates slightly convex and armed with spaced groups of rather slender papilliform spinelets, which, on a variable number of plates in the interradial areas form fasciculate or pectinate pedicellariae. The pedicellarian spinelets are coarser and shorter than the others.

Proximal adambulacral plates wider than long, then as wide as long, and beyond middle of ray increasingly longer than wide. Sutures very broad. Furrow spines 6 or 7, slender, compressed, pointed, and rather long. When there are 6, the spines are nearly equal, the median being a trifle the longest. When there are 7, either or both lateral members, especially at base of ray, are conspicuously shorter. Subambulacral spines 8 to 12, slender, pointed, much shorter than furrow spines and arranged in about 2 irregular series, or on the first 2 or 3 plates in 2 or 3 irregular transverse series, or without any regularity. A variable number of plates bear 1 or 2 fasciculate pedicellariae with 4 to 6 jaws. These jaws are slightly more pointed subambulacral spines. Rarely all the subambulacral spinelets form a sort of pectinate pedicellaria. In the type most of the plates except on the attenuate outer part of the ray have pedicellariae, but a specimen from station 5215 is poorly provided.

Mouth plates of the usual *Persephonaster* type. At the inner angle of the combined plates are 2 broad, flattened, blunt, petaloid spines. Between each of these and the peristome is an oblique vertical double row (or really a very acutely angular series, apex toward peristome) of about 10 pointed spinelets resembling a pectinate pedicellaria. The marginal series, on the furrow, at level of inner tooth, consists of 3 to 5 rather conspicuous slender lanceolate spines appressed against the smaller suboral spines, of which there are generally 2 series to each plate, that bordering the median suture consisting of 10 to 14 short, stout, blunt, spinelets. The other or intermediate series is less regular and is composed of 8 or 10 shorter spinelets. A third series continues the marginal series along the lateral suture. That the teeth are occasionally broken in life is shown by their absence on 2 mouth angles of the type, and by regenerating members in 2 other angles.

Madreporic body very convex, situated its own diameter nearer the margin from the middle of r.

Anatomical notes.—Intestinal coecum butterfly-shaped, the greatest diameter about one-half r. Polian vesicles rather large with numerous small diverticula scattered over the surface of the enlarged distal portion. Superambulacral ossicles slender, and rather long, but absent from the first 3 ambulacral ossicles. The intermarginal pores, described under *P. euryactis brevispinus*, are well developed, the largest being the median interradial, which as seen from the coelomic side has a diameter about one-third that of the plates adjacent. From the outside, when the plates are carefully cleaned, the pore is visible at the point where the transverse suture between a pair of superomarginals meets the intermarginal suture (between the 2 series), but is covered with skin. There does not seem to be any structure resembling a papula. The other pores are similar and decrease gradually in diameter, becoming very tiny at the middle of ray, and soon ceasing.

Type—Cat. No. 30526, U.S.N.M.

Type-locality.—Station 5123, east coast Mindoro, 283 fathoms, green mud; 2 specimens.

Distribution.—Known only from east of Masbate and east coast of Mindoro, and neighboring waters, 283 to 604 fathoms.

Specimens examined.—Six: 2 from type-locality and 4 from the following stations:

Station 5215, east of Masbate Island, 604 fathoms, green mud, bottom temperature 50.5° F.; 1 specimen.

Station 5219, between Marinduque and Luzon, 530 fathoms, green mud, sand; 3 specimens.

Remarks.—*P. oediplax* differs from such species as *euryactis*, *anchistus*, and *luzonicus* in having much narrower and more tumid superomarginals, each of which bears a subcentral conical spine, not an appressed spine or row ot spinelets near the distal border of the plate. The three species mentioned are notable for their broad inferomarginal plates also. *P. oediplax* differs from *P. tenuis* in having much smaller and more tumid [armed] superomarginals and less massive inferomarginals. The side of the ray of *tenuis* at base is massive and high—higher than the actinal width of inferomarginals—while in *oediplax* the border of ray is equal to or less than actinal width of inferomarginals. The ray is slenderer in *tenuis* and the paxillar area much narrower, the paxillae larger, the lateral spines more numerous, and the actinal inferomarginal spinelets squamiform. *P. multicinctus* belongs to another type, having massive transversely tumid superomarginals, narrow paxillar area, large independent abactinal pedicellariae, larger paxillae, and numerous furrow spines. *P. suluensis* also has a massive margin to the ray, the superomarginals, especially, being larger than in *oediplax*, and the side wall of ray higher. The paxillar area in *suluensis* is narrower; and conspicuous, independent, abactinal pedicellariae are present. Actinally the most noteworthy differences are the wider inferomarginals and longer marginal mouth spines of *suluensis*, and the slenderer inferomarginal spinelets and conspicuous inferomarginal pedicellariae of *oediplax*.

PERSEPHONASTER HABROGENYS Fisher.

Plate 13, fig. 1; plate 28, fig. 1; plate 31, fig. 6; plate 39, figs. 2, 2*a*–*e*.

Persephonaster habrogenys Fisher, 1913*a*, p. 618.

Diagnosis.—Resembling *P. oediplax* but with still slenderer rays, smaller disk, narrower inferomarginal plates, which bear proximally 2 or 3 actinal spinules in addition to the 2 or 3 slender, long, lateral spines; with very small actinal interradial areas, the plates extending less than half the length of ray; mouth plates small, with 2 series of suboral spines; adambulacral plates spaced, with 5, less often 6, furrow spines. Superomarginal spines proximally 1, distally 2 or 3, the plates markedly convex. No superomarginal, inferomarginal, or subambulacral pedicellariae. R=59 mm., r=11 mm., R=5.3+r; breadth of ray at base, 11 or 12 mm. Rays slender, evenly tapered, sharp; interbrachial angles abruptly rounded.

Description.—Paxillae arranged as in *oediplax*, but with a wider radial area free from papulae. Paxillae not crowded, medium sized, the largest having about 15 to 18 slender terete spinelets, often longer than the pedicel, 3 to 5 occupying the center of group. Many paxillae have part or all of the center of tabulum occupied by a fasciculate pedicellaria with 3 or 4 jaws, and a few are lower and have only 2 or 3 spinelets in addition to the pedicellaria.

Superomarginals, 35 in number, have about the same proportions as in *oediplax*, but are a trifle less tumid, and bear on the apex of the plate, nearer the inner than outer edge, a sharp conical spine, larger than in *oediplax*, and proximally two-thirds to three-fourths length of plate. Beyond the basal third of ray a second, and often a third smaller spine is added to form a transverse series, which as the end of the ray is approached, moves very gradually nearer the distal margin of plate. General surface of plate covered with delicate terete upright spinelets, becoming slightly longer, sharper, and slender-squamiform near the spines. Terminal plate slender, cylindrical, longer than wide, with a terminal spine longer than itself, and on either side 2 shorter spines.

Inferomarginal plates extending laterally slightly beyond the superomarginals, very narrow, with a tumid outer end, as in *oedi-plax*. Except for the first 2 or 3 plates which are wider than long, all the plates are either as wide as long (to about the middle of ray) or narrower than long (outer part of ray). For this genus the inferomarginals are very narrow, and form a narrow, slightly beveled, border to actinal area. Lateral spines proximally 3 (with sometimes a slenderer fourth spine at upper end of series) distally 2, slender, slightly curved, appressed, the lowest the longest and equaling 2.5 to 2.75 plates in length, on proximal half of ray. On the distal margin of the narrow actinal face of plate 2 or 3 much smaller, very slender spinules continue the lateral series. These become so small on the outer third of ray that they merge into the general spinulation, and owing to the extreme narrowness of the plates, the lateral comb occupies the whole width. The spinelets covering the outer or lateral face of plate are like those of the superomarginals, only a little longer, but actinally become coarser, sharper, and well spaced. There may be on the proximal plates an enlarged spinule near the adoral margin.

Actinal interradial areas very small for the genus, the distance between outer end of mouth plates and the edge of first inferomarginal plate being slightly less than the interradial dimension of the mouth plates. The series between the 2 points mentioned contains 4 or 5 plates. Intermediate plates extending to twelfth inferomarginal or a trifle less than half length of ray. These plates are spaced from one another, beyond the second inferomarginal. The plates bear groups of 6 or 8 slender, sharp, terete spinules, which, by reason of the investment, appear smaller near the base, and which are a little shorter than the subambulacral spines. Several plates in the interradial area, adjacent to adambulacrals, bear prominent fasciculate pedicellariae with 4 to 6 jaws swollen at the base and tapering like the other spinules, but the calcareous part in reality is very slender.

Furrow spines 5, occasionally 6, long, slender, compressed, pointed, membrane-invested and webbed at base, forming a regular comb with a curved outer margin. The mesial spines are about as long, on the proximal third of the ray, as the neighboring inferomarginal plate. Subambulacral spines very slender, terete, but apparently thick and swollen, owing to the translucent tissue investing them. There are about 6 of these forming 2 series on the second and third plates, then on the succeeding plates a single zig-zag series, and finally on the outer half or two thirds of ray 2 more or less irregular series, of 8 to 12 spinules. The first plate is compressed and has an angular furrow series of 5, and 2 transverse subambulacral series of about 8 or 9 spines. No subambulacral pedicellariae.

Mouth spines fewer than in *oediplax*. Laterally from the base of the compressed tooth, and directed into mouth of furrow is a fasciculate group of 4 or 5 small pointed tapering spinelets resembling and probably functioning as a pedicellaria. This is the usual *Persephonaster* group of spines belonging to the marginal series. It is continued on the margin of plate facing the furrow by about 3 longer, bluntly pointed spines, and thence along the lateral suture margin by 5 or 6 additional shorter slender spinelets. The superficial series, along edge of median suture, consists of about 8 prominent, flattened, slender or lanceolate blunt spinules decreasing in length toward outer end of plate. The mouth plates are much narrower than in *oediplax*, or any other of the preceding species, and are notable for their small size generally. The distance between the superficial and marginal series of spines is slight.

Madreporic body small with coarse striae and a paxilla on the surface adjacent to the adcentral margin. It is situated about two-thirds r from center.

Type.—Cat. No. 30527, U.S.N.M.

Type-locality.—Station 5114, Verde Island Passage, vicinity of Balayan Bay, southern Luzon 340 fathoms, fine sand; 2 specimens.

Distribution.—Balayan Bay, Luzon, and Sibuko Bay, Borneo, 305 to 340 fathoms.

Specimens examined.—Three, the types and 1 from 5592, Sibuko Bay, Borneo (lat. 4° 12′ 44″ N.; long. 118° 27′ 44″ E.), 305 fathoms, green mud, bottom temperature 43.3° F.

Remarks.—This species is an aberrant *Persephonaster* in that its marginal and mouth plates are distinctly smaller than the mean for the genus, and the general habit is slender and light. The actinal interradial areas are also small, and the furrow spines of the adambulacral plates reach the lowest number known in the genus. *P. habrogenys* agrees with *P. gracilis* (Sladen) in having small mouth plates, but differs in possessing armed superomarginals, smaller disk, higher paxillae; in having the lateral and ventral facets of the inferomarginals better differentiated, and the long inferomarginal plates lateral in position; in having fewer furrow spines. The marginal plates of *gracilis* are much less tumid than those of *habrogenys*. *Dytaster anacanthus* Alcock and Wood-Mason (Bay of Bengal, 1,748 fathoms) is certainly not a *Dytaster*. Although the mouth plates are imperfectly described, the species, as Alcock states, seems to be near *P. gracilis* (Sladen) and for that reason, if for no other, probably should occupy a niche in the genus *Persephonaster*. It has unarmed superomarginals which are more lateral in position than in *habrogenys* and are not tumid. The lateral inferomarginal comb is reduced to a long, fine spine and 1 or 2 similar but smaller ones are vertically below it; furrow comb, 6 to 8 spines; no pedicellariae. In *habrogenys* the lowest lateral spine is the longest.

PERSEPHONASTER MONOSTOECHUS Fisher.

Plate 20, fig. 2; plate 21, fig. 2; plate 31, fig. 5; plate 37, figs. 3*a–c*.

Persephonaster monostoechus FISHER, 1913*a*, p. 620.

Diagnosis.—Related to *P. croceus* Alcock and Wood-Mason, which it resembles in having, in addition to the appressed inferomarginal spines, a conical erect lateral spine, but differs in having only 1 series of erect superomarginal spines (peculiarly situated), narrower marginals, 8 furrow spines, small actinal interradial areas, and irregularly occurring and smaller, erect, lateral spines. R=45 mm., r=8.5 mm., R=5.3 r; breadth of ray at base, 12 mm. Rays rather slender, with, proximally, high lateral walls sloping steeply but not quite perpendicularly; marginal plates massive, tumid, the superomarginals encroaching conspicuously upon the abactinal surface beyond the base of ray. Interbrachial angle abruptly rounded.

Description.—Paxillar area narrow, being about as wide at the base of ray as the length of the first superomarginals. Paxillae comparatively large, though the number of spinelets is not great. Paxillae largest in the interradial regions and adjacent portions of ray. The base of the stout tabulum is roundish on the disk, with slight indentations, but on the ray the plate as well as the section of tabulum is elongate elliptical and the tabulum or pedicel becomes lower and lower on the outer part of the ray until the plates are merely slightly convex. A large interradial paxilla has 15 to 18 pointed slender spinelets about as long as the convex tabulum, 3 to 5 occupying the center. In the center of disk, where the paxillae are small and the pedicels are slender instead of thick, there are 5 to 10 slender spinelets. The large paxillae extend far along ray on either side, but are compressed instead of round. On the radial region of each ray are several large fasciculate pedicellariae, sometimes broader than paxillae, composed of 4 to 8 pointed tapering spinelets, much stouter than those of paxillae, and springing from low plates resembling reduced paxillae.

Superomarginal plates, 28 in number, are fairly large and tumid, the first 4 or 5 being confined to the side wall of the ray and bearing their single upright conical spine practically on the upper edge of the plate; but with the fifth plate the spine recedes from the inner edge, and more and more of the surface of the plate is abactinal. With the eighth or ninth plate the 2 facets are about equal, but distally from this point the dorsal becomes much the wider, and the spine, which always keeps on the well-rounded margin between the 2 facets, gradually becomes horizontal and has the appearance of being a lateral spine. There is no abrupt fasciolar channel between the plates, the surface sloping upward from either transverse suture to the median line and the spine is on this ridge, which, however, is slight on the outer third of ray. The spine is tiny or wanting on the last 8 or 10 plates. The longest spines, in the median third of ray, are about as long as the plate, and the plates themselves are nearly square, except at the base and end of ray, where the transverse dimension is the greater. The surface of plate is covered with spaced delicate spinelets fairly capillary around the edges and a little shorter and more clavate in the middle. Terminal plate rather stout with a tuft of 10 or 11 sharp spinules in 2 semicircular series at the end.

Inferomarginal plates rather small, the proximal being a trifle wider than the corresponding superomarginals, the rest of about the same width and length. All except the distal plates are markedly tumid, the ridge of the superomarginals being continued across the lower series, and the ventral margin of the ray is so evenly rounded that the plate is regularly curved from the inner to the outer edge, there being in consequence an exceptionally narrow actinal face when the specimen is viewed from below. The armature is of the type of *P. croceus* and quite distinct from that of the foregoing species. Just below the outer or upper edge of the plate is a horizontal, erect, conical spine a little smaller than the corresponding superomarginal. Below this, and forming with it a slightly oblique transverse comb, are 2 (sometimes 3 and distally only 1) slender, appressed, slightly flattened, sharp spines, the upper about as long as width of plate. The erect conical spine is often missing, there being no regularity in this respect, and on the outer part of the ray it is regularly lacking. When lacking on the proximal part of the ray its place is sometimes, but not always, taken by an extra appressed spine. The plate is covered with delicate spinelets similar to those of the superomarginals but a little longer on the ventral end.

Actinal interradial areas small, the interradial diameter slightly exceeding that of the mouth plates. Intermediate plates extending in a single series to the eighth inferomarginal (a little over a third of ray) and in 2 series to the fourth inferomarginal. Five plates between the first inferomarginal and mouth plate. Plates covered with spaced delicate spinelets; several plates in each angle also with a central slender, much longer, pointed appressed spinule.

Furrow spines 8 (occasionally 7 or 9), long, slender, slightly compressed and pointed, in a regular comb with a nearly straight distal margin. The spines are about as long as width of plate at base of ray and slightly longer distally. Subambulacral spinules 10 to 12, very slender, terete, pointed, in 3 irregular longitudinal series or in 1 series of 5 near furrow, and the others without very definite order, the size grading from those of first series, which are nearly as long as the furrow spines, to the outer, which are subequal to the actinal intermediate spinelets. Some of the proximal plates have fasciculate pedicellariae with 3 to 5 shortened, sharp spiniform jaws. The first plate is not very markedly compressed and has a furrow series of 6.

Mouth plates rather narrow but very convex. The oblique vertical angular series of marginal spines forms a fasciculate group of about 5, the outer limb of the angle being continued along the margin adjacent to first tube foot by 3 to 5 additional slender spinelets, in a fan, and thence along the lateral sutural margin, by 7 or 8 delicate spinelets. The inner tooth is stout, fusiform, blunt, or pointed, about half as long as plate. The suboral armature includes a series of 8 or 9 short, rather thick, spines along margin of median suture, the innermost two-thirds as long as the tooth, the others rapidly decreasing in length. There is also an intermediate series of 6 to 8, subequal to the adjacent superficial spinelets, but not very regular in size or shape.

Madreporic body a little more than its own diameter from margin, the ridges with small spiniform protuberances.

Type.—Cat. No. 30528, U.S.N.M.

Type-locality.—Station 5606, Gulf of Tomini, Celebes, 834 fathoms, green mud; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—*P. monostoechus* may be readily distinguished from any of the preceding species by the presence of the erect lateral inferomarginal spine, and by the single series of erect superomarginal spines which are at first dorsal in position and gradually move away from the upper edge of the plate and become lateral on the outer part of the ray. The superomarginals are formed very much like those of *multicinctus*, but the position of the spine, as well as the inferomarginal armature, will at once distinguish *monostoechus*.

Persephonaster croceus Alcock and Wood-Mason is from the Gulf of Manaar, 738 fathoms.

Genus TRITONASTER Fisher.

Tritonaster Fisher, 1906, p. 1017. Type, *T. craspedotus* Fisher.

TRITONASTER EVORUS Fisher.

Plate 29, figs. 1, 4; plate 30, fig. 6; plate 39, figs. 3, 3*a–b*.

Tritonaster evorus Fisher, 1913*a*, p. 621.

Diagnosis.—Rays 5. R=31 mm., r=7 mm., R=4.4 r; breadth of ray at base, 7.5 mm. Rays pointed, fairly stout, very evenly tapering from narrow base; interbrachia abruptly rounded, abactinal integument thin, slightly inflated; paxillae small, largest on borders of paxillar area to which papulae are confined; marginal plates massive; superomarginals forming a tumid border to paxillar area, each with a small, conical, upright spine; inferomarginals with very tumid outer ends bearing, proximally, 2 curved parallel combs of setalike spines (one covering the other) and, distally, 1 such comb; adambulacral plates with 3 long furrow and 12 to 15 delicate subambulacral spines, the latter often forming fasciculate pedicellariae. Differing from *T. craspedotus* in the much larger, tumid superomarginals, smaller paxillae, double proximal combs of lateral spines, fewer adambulacral spines and fewer enlarged teeth.

Description.—Paxillae small, not compact, smallest over a wide radial area and center of disk, where there are no papulae, and distinctly larger on the papular area which comprises only the border of the paxillar area. Paxillae are rather low parapaxillae, the summit of the tabulum being convex and narrower than the base. The larger paxillae have 1 to 4 central, delicate, minutely thorny spinelets and 6 to 9 peripheral, while the small ones have 1 to 3 central and 5 to 8 peripheral. The small paxillae differ, however, in having a much lower tabulum and shorter spinelets than those of the papular areas. Some of the very small paxillae have only 2 or 3 minute spinelets. The paxillae of papular areas are arranged in oblique transverse rows, but this arrangement ends abruptly at the edge of the papular areas; the other plates are irregular. The paxillae are smaller than those of *T. craspedotus.*

Superomarginal plates, 21 to a ray, are, unlike those of *craspedotus* robust to the end of the ray and are so shaped that they form a raised angular or tumid border to the paxillar area. The plates are wider than long, and each has a lateral and a dorsal face, the latter being about square and the former longer than high beyond the basal fourth of ray. Each plate bears on the angle between the 2 faces an upright conical sharp spine about half as long as the plate. This spine stands on the center of the plate at base of ray and gradually moves near the distal margin as the extremity is approached. The general surface of plate is covered with well-spaced, tiny upright spinelets, very fine about the borders of the plate and gradually becoming thimble-shaped at the center. On the lateral face of many plates are 1 or 2 small fasciculate pedicellariae with about 6 tiny spinelets for jaws. The fascioles between the plates are very rudimentary.

Inferomarginal plates wider than long, and a little wider in proportion to length than in *T. craspedotus.* They have a very convex outer end which defines the ambitus and bears a perpendicular, curved comb of delicate curved setalike spines. On the second to fifth plates this comb covers a second parallel comb of smaller spines.

as in *Ctenophoraster*. This second comb is not found in *T. craspedotus*. Proximally the first comb consists of about 5 larger spines, the third from the upper the longest; and forming a continuous series with these on the distal margin of the actinal surface are 3 or 4 smaller and more delicate ones. In front of them is a row of slightly enlarged spinelets. Beyond the eight or ninth plate, only the lateral comb remains and consists of 5 or 4 spines, and 3 or 4 at the very tip. Owing to the tumidity of the outer end of the plate 2 or 3 of these spines are dorsal in position and are pressed against the sloping side wall of the superomarginals. The second comb is confined strictly to the first 4 or 5 plates, and to the outer end, forming a parallel series between the base of the regular comb and the distal edge of plate. There are 3 or 4 smaller spinules to the series; rudiments of these spines persist to about the ninth plate. The spinelets covering the surface of the plates are spaced and very delicate. On the upper surface of the tumid outer end, near the first lateral spine a tiny fasciculate pedicellaria often occurs.

Terminal plate longer than wide, and ovoid in shape with a truncate narrower end: proximal end with a slight notch next to paxillar area, shallower than in *craspedotus*.

Adambulacral plates proximally wider than long, gradually becoming narrower, until distally they are longer than wide. Furrow spines 3, very long. The central one compressed, and almost truncate. The laterals slender, slightly tapered and blunt. One or two subambulacral spines stand on the margin owing to the very salient furrow angle of the plate. These are usually bent away from the 3 furrow spines. On the surface of the plate are from 12 to 15 shorter, very slender spines, decreasing in length toward outer edge of plate. These are variously arranged, sometimes in 2 longitudinal series of 3 or 4 each, with 4 or 5 smaller spinules on the outer part of the plate. The distal member of the first series stands on the aboral facet of the angular margin; or 4 to 6 spines on the aboral side of the plate form a fasciculate pedicellaria. This is composed of 1 or 2 spines from each of 2 or 3 longitudinal series. On the outer half of ray the pedicellaria is rare, and the spinules are in 2 series with some irregular ones behind them, or in 3 series. The spines are less numerous than in *craspedotus*, and the pedicellariae are higher.

Mouth plates relatively a little smaller than those of *craspedotus*. There are 2 large teeth to each pair of plates; all the other spines are much slenderer and shorter. Furrow series angular as in *craspedotus*, composed of rather slender spines bent upward, and continued to outer end of plate along suture adjacent to first adambulacral in 8 to 10 smaller spaced spinelets. The series along the median suture consists of about 10 to 12 slightly clavate spines and between them and the marginal series is an irregular intermediate series of smaller spines, nearer the size of the nearest marginals. The inner superficial spines of *evorus* are smaller than those of *craspedotus*, there being but 2 enlarged teeth at each mouth angle, while in *craspedotus* there appears to be a double phalanx of numerous teeth.

Actinal interradial areas small, the distance between the mouth plates and inferomarginals being less than width of the latter. No odd interradial series of actinal intermediate plates. A single series of rudimentary plates extends to the sixth inferomarginal or about one-fourth the length of ray measured along side, and a second series does not go beyond the second. The outermost plates are separated one from another. There are only 3 plates in an interradial direction between the mouth plates and first inferomarginals. Externally the plates are convex, roundish, or elliptical, with indications of 4 or 5 sides, and are armed with spaced delicate spinules similar to those of the inferomarginals; most of the plates nearest furrow bear a prominent central fasciculate pedicellaria.

Madreporic body very small, situated its own diameter from marginal plates, with few deep striae (deeper than in *craspedotus*) radiating from an eccentric point near the adcentral side. Anal aperture minute.

Type.—Cat. No. 30529, U.S.N.M.

Type-locality.—Station 5476, off extreme southeastern end of Luzon (vicinity of San Bernardino Strait), 270 fathoms, fine sand, bottom temperature 48.3° F.

Distribution.—Known only from the type-locality.

Remarks.—This species preserves the generic facies, with the exception of the superomarginal plates which are much larger than in the only other known species, *T. craspedotus* from the Hawaiian Islands. Further differences are the smaller paxillae, the double comb of lateral spines of the proximal inferomarginals, the additional actinal members of the primary comb, fewer adambulacral spines, and higher subambulacral pedicellariae, fewer enlarged teeth, and smaller madreporic body. The actinal interradial areas are a little smaller, and the inferomarginals a little wider. *T. craspedotus*, as well as *evorus*, has both superomarginal and inferomarginal fasciculate pedicellariae, though very inconspicuous. The superomarginal spinelets of *evorus* are shorter and coarser on the central part of the plate, the superomarginal spine larger, and the inferomarginal spinelets a trifle finer and more spaced than in *craspedotus*. Owing to the smaller size, in *craspedotus*, of the distal superomarginals, the lateral spines encroach more upon the abactinal surface.

Although *Tritonaster* is near *Persephonaster* it differs in having the abactinal plates a reduced form of paxilla, in having the papulae confined to a limited area around the borders of the paxillar space, leaving much of the disk and a conspicuous radial band entirely free, in having the actinal intermediate plates reduced to rudiments on the ray, and in having a decidedly Astropectenlike type of adambulacral armature. When the genus was instituted I thought the small superomarginals were of generic importance, but such has proved not to be the case. The curious lateral combs of inferomarginal spines and the extremely tumid plates are characteristic of the two species, and are an exaggeration of what occurs in some species of *Persephonaster*. If *T. evorus* approaches *Persephonaster* in the superomarginals it departs even more than *craspedotus* in its Astropectenlike adambulacrals, reduced paxillae, and rudimentary actinal intermediate plates.

Genus ANTHOSTICTE Fisher.

Anthosticte Fisher, 1911*c*, p. 417. Type, *A. aulophora* Fisher.

Diagnosis.—Near *Tethyaster* but distinguished by the presence of very deep marginal fascioles, the absence of a regular midradial series of enlarged paxillae, the extension of the gonads to end of ray, and the character of the paxillae, which are tall and slender. Superomarginal plates without specialized spines; inferomarginals with a single transverse row of small, flattened, sharp, appressed spines; fascioles between marginals very deep, lined with small spinelets and in continuation of the actinal fasciolar channels. Abactinal plates stellate, the shaft of paxilla tall, slender, and crowned by a floriform group of slender spinelets; papulae all over abactinal surface. Actinal intermediate plates extending nearly to end of ray, and traversed, between marginals and adambulacrals, by deep channels; no enlarged actinal intermediate spines; an incipient series of odd interradial actinal plates; adambulacral plates with a very prominent furrow angle and an astropectinoid armature; no enlarged subambulacral on distal portion of ray; fascioles between the adambulacral plates shallow and not lined with spinelets, as in *Sidonaster*. Tufts of gonads extending to end of ray. Madreporic body not concealed. Superambulacral plates large. Tube feet pointed, with simple rodlike deposits at tip. Small spiniform abactinal pedicellariae.

ANTHOSTICTE AULOPHORA Fisher.

Plate 17, fig. 1; plate 18, fig. 3; plate 19, fig. 2; plate 38, fig. 3; plate 39, figs. 1, 1*a*–*d*.

Anthosticte aulophora Fisher, 1911*c*, p. 417.

Diagnosis.—Rays 5. R=162 mm., r=34 mm., R=4.76+r; breadth of ray at base, 40 mm., at tenth superomarginal, 29 mm. Disk moderate, rays long, rather narrow beyond interbrachium, tapering very gradually to a bluntly pointed extremity; sides of ray and disk evenly rounded; abactinal surface slightly convex; paxillae fairly close-set and large, floriform, with slender tall pedicels: superomarginals without special spines, but with small spiniform pedicellariae; inferomarginals with transverse series of 2 to 5 small appressed spines; marginal fascioles very deep and separated by thin high ridges; actinal fascioles deep; actinal interradial area extensive, the plates with thin high keels covered with slender spinelets; furrow spines usually 5, long, compressed; subambulacrals 5 to 7; madreporic body exposed; tube feet with deposits; gonads extending to end of ray.

Description.—Paxillae fairly compact, and touching, with a slender, tall pedicel crowned by a floriform group of 15 to 20 peripheral, and 5 to 15 or even more central, terete, blunt spinelets, the latter often in a compact group resembling a pedicellarian apparatus, the former radiating like the rays of a composite flower. On most of the paxillae 2 to 4 central spinelets are slightly modified with broader tips, and form actual pedicellariae. The paxillae are unusually uniform in size, and are only slightly smaller at the end of the rays. The largest seem to be those of the interradial areas of disk and proximal third of ray, those of center of disk and adjacent radial areas (as far as base of ray) being slightly smaller.

The slender pedicels spring from 6-lobed (stellate) plates, these without definite order on center of disk and midradial region, but elsewhere in oblique transverse rows parallel to interradius. On the ray these series are slightly spaced, and consecutive plates of a row barely touch. In the midradial area the plates sometimes touch or are separated. There is no definite radial series of plates as in *Tethyaster subinermis.* Papulae distributed all over abactinal surface, as in *Dipsacaster* (not absent from midradial line or center of disk), single, 5 or 6 about each plate.

Marginal plates of the two series corresponding, with unusually deep fasciolar channels separated by thin high ridges, each of which is composed of the elevation of a combined superomarginal and inferomarginal plate and is thinner than the intervening channels. The height of this ridge above the bottom of the channel equals about one-half the dorsoventral dimension of the combined marginal plates. Superomarginals forming a rounded bevel as in *Tethyaster subinermis,* covered with short, clavate, papilliform spinelets, becoming slenderer on edge of grooves. Most of the plates bear 1 to 3 pedicellariae, composed of a couple of slightly modified spinelets, stouter than the others. Sometimes the pedicellaria is pectinate with 4 to 6 spinelets. These pedicellariae closely resemble those of the paxillae, but are larger. Spinelets in grooves very numerous and delicate. Superomarginals, about 80. Terminal plate heart-shaped from above, broader than long, and with a shallow notch at both ends. The superomarginals underlie the proximal half.

Inferomarginals projecting slightly beyound superomarginals on outer part of ray, and forming a rounded bevel to margin of actinal surface, being about one and one-half times wider than upper series. They are covered with a transverse series of 2 to 5 (usually 2 or 3 distally, and 2 to 4 proximally) small, flat, lanceolate, sharp, appressed spines and numerous shorter, slenderer, slightly flattened, blunt spinelets, which on median line of plate are much longer than those of superomarginals. The spinelets lining the deep fascioles are similar to those of upper series. At the upper end of nearly all the inferomarginals, close to the lower or outer margin of the superomarginal, is a pedicellaria with 2 (less often 3 or 4) blunt, slightly tapered or often clavate spiniform jaws. These pedicellariae are larger than those of the superomarginal plates.

Actinal interradial areas fairly large, but rather abruptly narrowing at base of ray, along which two series of intermediate plates extend two-thirds of its length, while one series continues nearly to the extremity. Between the first inferomarginal and the second adambulacral the series contains 7 to 9 plates. There is an incipient odd interradial series of actinal intermediate plates. Behind the mouth plates there is a pair of plates, and from between the outer ends of these extends an odd series of 2 or 3 plates, the whole being wedged between the inner ends of the series leading from the first inferomarginals to the second adambulacral. The odd series is quite inconspicuous. Deep channels lead from the marginal fascioles to the fascioles between the adambulacral plates, these being separated by single rows of intermediate plates. The marginal and adambulacral plates do not correspond, however. At the base of furrow the latter are slightly more numerous, while in the middle third, the former; distally they correspond. The high keel of the intermediate plates which forms the ridges between the channels is covered with slender, long, terete, or slightly swollen, blunt spinelets directed toward ambitus, and similar to those of inner end of inferomarginals. The channels are not lined with spinelets, as are the marginal fascioles, but they are thickly roofed by terete, delicate spinelets, smaller than those on the exposed edge of the keel.

Adambulacral plates astropectinoid, with an acute furrow angle, bearing a compressed blunt saber-shaped spine, and on either side of this, two strongly compressed rather slender blunt spines. Sometimes a third is added, making the total 5 to 7. Surface of plate with 5 to 7 more cylindrical, slender, blunt spines, one forming a series with the second lateral furrow spines, the rest disposed in about two longitudinal series behind this, the laterals of the first series often standing on margin and making on either side the supernumerary furrow spines. The plates are wider than long, well spaced, with a shallow channel between, over which extend several to many small terete spinelets belonging to the transverse margins of plates, and not calculated in the above spine counts.

Mouth plates prominent, densely covered with spines, increasing in length toward inner end of plate, where, directed over actinostome, is a cluster of teeth. Marginals 7 or 8, distally with flat side to furrow, but at inner end of plate more knife-shaped and with edge thereto.

Madreporic body exposed, medium-sized, with fine radiating striae. The ridges near center bear low tubercular prominences. It is situated about one-third R from margin.

Gonads disposed in independent tufts attached to the abactinal integument on either side of the median radial area and extending to end of ray. Ampullae strongly two-lobed. Tube feet pointed, with deposits at the tip in the form of small, simple, straight, curved, or irregular rods. Superambulacral plates well developed.

Type.—Cat. No. 28656, U.S.N.M.

Type-locality.—Station 5420, between Cebu and Bohol (lat. 9° 49′ 35″ N.; long. 123° 45′ E.); 127 fathoms; bottom temperature, 59° F.

Distribution.—Known only from the type-locality.

Remarks.—The genera *Moiraster*, *Tethyaster*, *Sideriaster*, and *Anthosticte* agree in having unarmed superomarginals, inferomarginals with a few small enlarged spines, naked madreporite, large actinal interradial areas, and intermediate plates far along ray, marginal and actinal fascioles, true paxillae, stellate abactinal plates, an astropectinoid adambulacral armature, and probably also in having the single papulae uninterrupted all over the dorsal surface. The first two seem to be a little more closely related than either is to the last two, while *Sideriaster* and *Anthosticte* are possibly also nearly related. Unfortunately there is but one species in each genus, and it is difficult to ascertain what characters are of generic importance. Applying the standards used in other and larger genera, *Anthosticte* differs from *Tethyaster* chiefly in having very deep marginal fascioles, gonads to the end of the ray, and no midradial series of enlarged paxillae. *Anthosticte* has taller and more delicate paxillae, but this may not be of generic importance. Its special points of agreement in addition to the characters listed above are the deposits in the tube feet (not recorded for *Moiraster* and *Sideriaster*) and shallow interadambulacral fascioles and an incipient odd interradial series of actinal intermediate plates, less prominent and regular than in *Tethyaster*.

Anthosticte differs from *Sideriaster* Verrill in having very deep marginal fascioles, shallow interadambulacral fascioles, no distally enlarged subambulacral spine. Neither the deposits in the tube feet nor the gonads of *Sideriaster* are described—one of the unfortunate results of drying unique specimens. I do not know whether *Sideriaster* has the incomplete unpaired interradial series of actinal intermediate plates. The fascioles between the adambulacral plates, which I examined in the type-specimen, form one of the most striking features of the genus. They are densely lined with small delicate spinelets, and are therefore similar to marginal fascioles. Such is not the case in *Anthosticte*, *Tethyaster*, or *Moiraster*.

The distribution of gonads and deposits of tube feet are unknown in *Moiraster*. Koehler describes the marginal fascioles as "peu profonds," while Sladen says they are deep, but the discrepancy is only apparent, for Sladen knew no genera with very deep fascioles, such as *Dipsacaster*. *Anthosticte* differs from *Moiraster* in respect to the marginal fascioles and the thin elevated intervening ridges of the marginal plates. The inferomarginal and actinal spinelets of *Anthosticte* are slender, and not flat, spatulate, and chisel-shaped. No pedicellariae are described for *Moiraster*. If the gonads are found to extend to the end of the ray, it may become necessary to unite the two genera, although the difference in the marginal fascioles will remain. The paxillae of *Moiraster* are probably lower than those of *Anthosticte*, and less delicate. The character of the gonads is important, and is apparently very reliable for generic groups, but not for higher ones.

It seems better to keep *Anthosticte* separate rather than to unite it with another genus, especially as it is not at all evident into which of the three groups it would go with the least disturbance.

The following table recapitulates the characters mentioned above. Will some one enlighten us concerning the gonads and tube feet of *Moiraster* and *Sideriaster*?

Comparison of the characters of Anthosticte, Tethyaster, Sideriaster, and Moiraster.

Genus.	Gonads extend to end of ray.	Gonads confined to proximal half of ray.	Marginal fascioles deep.	Adambulacral fascioles shallow.	Deposits in tube feet.	Distal subambulacral spines enlarged.	Paxillae tall; pedicel slender.	Paxillae rather low; pedicel stout.	Midradial row of enlarged paxillae.	An incomplete odd interradial series of actinal plates.
Anthosticte	×	....	×	×	×	....	×	....	....	×
Tethyaster	....	×	....	×	×	....	....	×	×	×
Sideriaster	(?)	(?)	....	....	(?)	×	×	....	....	(?)
Moiraster	(?)	(?)	....	×	(?)	....	×	....	....	×[1]

---

[1] According to Koehler, Trans. Roy. Soc. Edinburgh, vol. 46, 1908, pt. 3, p. 631, pl. 12, fig. 110, this series seems to be present in an incipient form.

Genus DIPSACASTER Alcock.

Dipsacaster ALCOCK, 1893, p. 87. Type, *D. sladeni* Alcock.

KEY TO THE SPECIES OF DIPSACASTER HEREIN DESCRIBED.

a.[1] Paxillae with very numerous, long, slender, terete, sharp spinelets; no differentiated marginal spines.
  b.[1] Rays narrower; odd interradial series of actinal intermediate plates nearly or quite reaching the margin; paxillar spinelets shorter and less delicate; furrow spines, 7 or 8 .... *nesiotes*, p. 145.
  b.[2] Rays broader, not narrowed at base; odd interradial series of actinal intermediate plates reaching only a little more than halfway to margin; paxillar spines very delicate and sharp; furrow spines, 8 or 9. *imperialis*, p. 146.
a.[2] Paxillae with upward of 25 short, blunt, clavate, or subterete, thorny spinelets; 2 or 3 small differentiated marginal spinules ...... *diaphorus*, p. 152.

DIPSACASTER NESIOTES Fisher.

Plate 41, fig. 2.

Dipsacaster nesiotes FISHER 1906, p. 1026, pl. 9, fig. 3, 3*a*; pl. 10, fig. 2, *a–b*; pl. 12, fig. 1, 2.

Specimens examined.—Two, one from each of the following stations:

Station 5623, between Gillolo and Makyan Islands, Molucca Islands (lat. 0° 16′ 30″ N.; long. 127° 30′ E.), 272 fathoms, fine sand, mud.

Station 5624, near above locality (lat. 0° 12′ 15″ N.; long. 127° 29′ 30″ E.), 288 fathoms, fine sand, mud.

Distribution.—Hawaiian Islands and Molucca Islands, 272 to 308 fathoms, fine sand and mud.

Remarks.—This species was taken by the *Albatross* in 283 to 308 fathoms among the Hawaiian Islands. None of the specimens were as large as that from station 5624, which is a veritable giant, having R=182 mm., r=58 mm., and R=3.14 r. The example from station 5623 is the same size as the type. In this example the superomarginals are very slightly wider than those of type, but there is variation among the Hawaiian specimens. The large example has narrower superomarginals even than the type, and matches a specimen from station 3908, Hawaiian Islands.

A characteristic of both young and adults of this species is the fact that the interradial series of actinal intermediate plates very nearly or quite reaches the margin at the interradial inferomarginal suture. The rays are narrower than in most other species and usually are narrower at base. The figure of the type shown in figure 2 of plate 10, Hawaiian Starfishes, is a little misleading. Plate 12 is better. In the first figure the ray is drawn a little too broad.

Although the species resembles *Dipsacaster sladeni*, I think it is perfectly distinct. The main differences are as follows: *Sladeni* has definite inferomarginal spines which form transverse series on the proximal plates. Alcock writes (and the figures bear him out) that the marginal plates correspond plate to plate. In *nesiotes* the two series do not correspond, but even alternate on the outer part of ray. The actinal intermediate plates of *nesiotes* are not very strongly carinated, but the character is such a comparative one that it would be difficult to apply without direct comparison of specimens. The furrow spines of *sladeni* are "needlelike," but in *nesiotes* very conspicuously compressed and bladelike. The subambulacral spines can scarcely be said to form a "rosettelike or paxillalike group of about 12." There is a very definite longitudinal series, just back of the furrow spines, of 3 to 5 shorter, terete tapering spinules, and back of this 12 to 18 spinules in 2 or 3 irregular series, or more or less scattered. They do not suggest a rosette or a paxilla and are moreover more numerous than in *sladeni.* The interbrachia of *nesiotes* are more open and rounded, owing to the peculiar form of the rays.

DIPSACASTER IMPERIALIS Fisher.

Plate 32, figs. 1, 2; plate 40, figs. 1, 1*a*–*b*; plate 41, figs. 1, 1*a*.

Dipsacaster imperialis FISHER, 1917*b*, p. 89.

Diagnosis.—Differing from *D. nesiotes* Fisher in having broader rays, more delicate, longer, and sharper paxillar spinelets; in averaging 1 or 2 more true furrow spines to the plate, and in having an odd interradial series of actinal intermediate plates which reach only a little more than half the distance between outer end of combined mouth plates and inferomarginals. Differing from *D. sladeni* Alcock in respect to the inferomarginal spines, which are smaller and do not form a definite transverse series, especially on the proximal plates; in having the distal marginals alternating, instead of opposite, and in having more numerous actinal intermediate plates on the ray, the second longitudinal series extending to the twenty-third or twenty-fourth inferomarginal, and the third extending to the sixteenth. R=160 mm., r=55 mm., R=3 r; breadth of ray at base, 62 mm. Rays broad at base, tapering from arcuate interbrachia, at first rapidly then more gradually to a subacute extremity.

Description.—The ray is a little broader at the base than in *sladeni*, the interbrachia more rounded, and the tip more pointed. The border formed by the marginal plates is wider, so that on the outer part of the ray the paxillar area is no broader than in *sladeni.* The paxillae are fairly uniform in size on the disk, though a trifle smaller at the center than midway to margin; from the latter point they decrease gradually as the margin is approached. The paxillae have a fairly stout, high, convex pedicel, which is broader at the summit than at the surface of the integument, and is crowned with a brushlike group of very many, very sharp, slender spinelets. About 85 were counted on an average large paxilla from the disk, and the peripheral spinelets, which are blunt and only about one-fifth the length of the others, form 1 or 2 cycles covering the bases of the outermost spinelets. The height of the brush about equals that of the pedicel, and the spinelets are usually bent inward. The inner ends of the paxillae are small, so that when seen from the coelomic side they appear to be well spaced. The paxilla is expanded into a sort of flange above the lower end, this representing the "plate." On the sides of the paxillar area the contour of the plate is elliptical, sometimes with notched ends; on the radial area the plates are roundish, with here and there short lobes. Papulae distributed all over disk, without interruption at the radial line, where each area may have 1 to 3 papulae. Between the lateral oblique rows of paxillae the papulae form a regular zigzag series (1 to an area); but at base of ray and on disk they are arranged with 5 or 6 around any one plate.

Superomarginals 38 to 40, the first being about 2.5 times as wide as long, while at middle of ray the breadth is about 1.2 times that of length. In this respect the plates resemble those of *nesiotes* and *sladeni* and differ from those of *D. grandissimus* Goto. The transverse fascioles are very narrow, and appreciably shallower than in *nesiotes*. The surface of the plates is covered with a fine nap of small, sharp, delicate, appressed spinelets, like those of the paxillae, except in the middle of the plate, where they are only about half as long.

Inferomarginals extending laterally beyond the superomarginals and defining ambitus, forming a border about half as wide as the superomarginals. The abactinal surface is covered with spinelets like those of the superomarginals while the actinal surface is beset with shorter and thicker, very small, sharp, subconical, slightly squamiform spinelets, converging and increasing in length toward the aboral, marginal tumidity of the plate where there is a tuft of conspicuous spinelets as in *D. nesiotes*, 5 to 8 tapering, rather stout, and often sharp spinelets being of predominant size.

Actinal interradial areas large, tapering off gradually along the ray. The series adjacent to adambulacrals extends as far as the thirteenth to thirty-second inferomarginal or nearly to end of ray. The second series extends to the twenty-third or twenty-fourth, or three-fourths the length of ray, the third series to about the sixteenth inferomarginal or nearly half the length of ray. The front series extends to the eighth plate, or a fifth the length of ray, while a fifth series extends to the sixth plate. Between this point and the first plate the plates in each interradial series increase in number from 5 to 10. Back of the mouth plates is a pair of intermediate plates, and from these the odd series, containing 4 plates, reaches about halfway to the marginal plates. The intermediate plates have a convex ridge, not very high, bearing numerous lanceolate appressed squamiform spinelets, increasing in size toward the furrow.

Adambulacral armature: Furrow spines 8 or 9 (7 far along ray) rectangular in section, compressed, bluntly pointed, lanceolate in contour, the edge to furrow. The median 2 or 3 spines are a little longer than the base line of the series; the others are increasingly shorter toward either end of series. Subambulacral spines 25 to 30. Four to 6 slender, tapering, somewhat flattened, sharp spines, about two-thirds as long as the furrow spines, form a regular series just back of the furrow series. The remaining spinelets are much shorter and form 2 or 3 irregular longitudinal series, with several spinelets out of line, or there may be no definite arrangement.

The denuded mouth plates have a narrower inner end than in *D. nesiotes*, which has the actinostomial angle of the combined plates broad and rounded, very much as in *D. grandissimus* (Goto, 1914, pl. 8, fig. 137). The margin bearing the oral spines is longer than in *nesiotes* and *grandissimus*, especially in proportion to the edge adjacent to first adambulacral, while the angle formed by the posterior ends of the two plates is wider and extends farther inward than in either of the two forms mentioned. (See pl. 41, fig. 1*a*.)

Marginal mouth spines 10, similar to those of the adambulacral plates, but heavier toward the inner end. The convex surface is beset with numerous short, thick, granuliform spinelets, increasing in length at the inner end of the plates. Two or 3 flattened granuliform spinelets form a very simple pedicellarian apparatus over the median suture, near outer end of the plates.

Madreporic body large, 12 mm. in diameter, situated 14 mm. from inner margin of superomarginal plates and concealed by about 25 large paxillae standing on its surface.

Type.—Cat. No. 37037, U.S.N.M.

Type-locality.—Station 5115, Verde Island Passage, north coast of Mindoro, 340 fathoms.

Distribution.—Known only from the type-locality.

Remarks.—*Dipsacaster imperialis* is related rather closely to four species—*D. nesiotes*, *D. sladeni*,[1] *D. grandissimus*,[2] and *D. laetmophilus*.[3] The nearest relative seems to be *D. nesiotes*, although I have not been able to make comparisons directly with specimens of *D. grandissimus*. The squarish superomarginals characterize *sladeni*, *nesiotes*, *imperialis*, and *laetmophilus*, while *grandissimus* has these plates conspicuously broader than long on the rays. *D. sladeni* has larger inferomarginal spines which tend, at least proximally, to form transverse series, and differs in this respect from the other four. In addition to the differential characters mentioned in the diagnosis, *D. imperialis* has more subambulacral spines than *sladeni* (in which there are 12), and the latter has more elevated actinal intermediate plates. According to the description "each plate has the appearance of a very large, compact, and beautifully expanded glomerular paxilla, owing to the fact that the central carina of the plate bears a multitude of stiff, radiating spinelets arranged like the florets of a composite flower." In *imperialis* the elevated portion of the plate is too broad and the spinelets are too short to give this appearance; rather the mostly four-cornered plates look as if covered with squamiform granules.

---

[1] Alcock, 1893, p. 87, pl. 5, figs. 3 and 4; Andaman Sea, 250 fathoms.

[2] Goto, 1914, p. 252, pl. 8, figs. 136–139; pl. 9, figs. 140–141; off Misaki, Japan, 840 meters.

[3] Fisher, 1911*d*, p. 95, pl. 12, fig. 3; pl. 15, figs. 1, 2; pl. 52, figs. 3, 3*a*, 3*b*; pl. 53, fig. 2; south of Alaska Peninsula, 695 fathoms.

In *D. laetmophilus* the rays are broader, with a distally wider paxillar area. The superomarginals are narrower, with deeper fascioles, and they correspond to the inferomarginals on the outer part of the ray (as in *sladeni*). The adambulacral furrow spines are 7, thinner and more bladelike.

The principal differences between this species and *grandissimus* are contrasted below in parallel columns.

D. grandissimus.	*D. imperialis.*
Rays shorter and blunter, with a subangular interbrachium. R=2.5 r; in figure a little less.	Rays longer and sharper, with wide arcuate interbrachia; hence rays are narrower a short distance above base; R=less than 3 r.
Superomarginals from near middle of ray outward nearly twice as broad as long.	From proximal fifth of ray outward plates only slightly broader (1.2) than long.
Inferomarginals uniformly covered with a thick coat of very fine, somewhat flattened spines of a silky appearance.	Actinal surface of inferomarginals covered with very small, sharp, subconical and slightly squamiform, spinelets directed toward the ambitus and increasing in size toward the outer tumid margin where a tuft is enlarged on the aboral border. At the base of ray 5 to 8 tapering sharp spinelets are obviously of predominant size.
One of the larger paxillae near middle of disk with 45 spinelets.	One of the larger paxillae from disk with 85 spinelets (some with fewer, some with more).
Actinal intermediate plates 185 to each of the 5 areas; actinal spinelets very small, exactly like those of the inferomarginal plates.	Actinal intermediate plates (in slightly larger specimen) 260±; actinal spinelets swollen, papilliform, bent toward the ambitus, and more or less squamiform, with a broad, lanceolate contour and a rounded or pointed tip.

Subambulacral spines about 20.	Subambulacral spines 25 to 35, usually 25 to 30.
Mouth plates where denuded with a broad rounded inner end to the combined pair and no appreciable angle between the outer ends; spine bearing margin adjacent to furrow, shorter.	Mouth plates where denuded with a narrow inner end to the combined pair and a longer spine bearing furrow margin; a conspicuous deep angle between the diverging outer ends of the plates.

Dipsacaster pentagonalis Alcock, also from the Andaman Sea, differs in having conspicuous inferomarginal spinules and an enlarged subambulacral spine.

Dipsacaster magnificus (H. L. Clark)[1] is probably closely related to *D. imperialis*. Clark's type is of about the same size as that of *imperialis*, the measurements being R, 155 mm., r. 50 mm., R=3 r, breadth 45 to 50 mm.

The species of *Dipsacaster* lack large spines or other prominent tangible features for comparison, so that distinct forms may have a close superficial resemblance. This is the case with *D. magnificus*. In general appearance it greatly resembles *imperialis*, but judging from Clark's careful description the following differences exist:

Although *magnificus* is slightly smaller its madreporic body is 2 mm. broader, carries 50 instead of 25 paxillae on its surface, and is 9 instead of 14 mm. from the inner margin of the superomarginal plates. The latter are 46 or 47 instead of 39 or 40 in number. They are thus smaller than in *imperialis*. Of the inferomarginals Clark says: "Inferomarginals correspond in number and position with the superomarginals, but are much larger and project conspicuously beyond them; the interradial ones are 2 mm. long by 9 mm. wide (8 mm. wide in *imperialis*), while those near the middle of the arm are 3 mm. by 6 mm. (4 by 5.2 in *imperialis*); their covering consists of a close coat of short, flattened, blunt spinelets, much coarser than those on the superomarginals." In *imperialis* the spinelets are short, sharp, subconical, slightly squamiform, in general not much larger than the superomarginal spinelets except for a tuft on the aboral tumidity of each plate, these tufts giving a serrate appearance to the ambitus. Clark does not mention these enlarged spinules, and they are not discernible in the figures. The paxillae are a little larger than in *magnificus*, the glomerular tuft at the top being 1.5 mm. in diameter on the disk, where the spinelets are compact. There are 30 or 31 oblique transverse rows of paxillae meeting the first 10 superomarginals, or 3 to a plate (usually 2, but sometimes 3 in *magnificus*). In *imperialis* the oblique transverse series of plates on either side of the midradial line are very distinct. The plates virtually form chevrons pointing toward the center of disk, but the apexes of the chevrons are not defined, because the regularity of the plates is interrupted along the radial line, as is characteristically the case in *Dipsacaster*. There are no means of comparing the form of the mouth plates, which would probably give valuable data. While no record is made of the internal anatomy of *magnificus*, I think there is little doubt that it is a typical *Dipsacaster*.

---

[1] *Lonchotaster magnificus* Clark, 1916, p. 30, pl. 6, figs. 1 and 2; Great Australian Bight, 80–120 fathoms.

Lonchotaster forcipifer Sladen is based on what is probably an immature specimen. *L. tartareus* is the first species mentioned, and may serve as the genotype, since none was designated. The genus, as based on *tartareus*, appears to be a near relative of *Dytaster*. There is a small spine on each marginal plate, and one on most of the actinal intermediate plates. (See Sladen, 1889, pl. 16.)

In this connection it might be well to state the characters which differentiate *D. sladeni* and *D. lactmophilus*, two forms very similar in general habit. I have compared specimens.

D. lactmophilus.	*D. sladeni.*
Spinelets of inferomarginals flattened and narrow-squamiform on actinal surface, becoming rather broadly squamiform on the plates of proximal third of the ray. These spinelets overlap and become larger from the inner edge toward the ambitus.	Spinelets of inferomarginals uniformly very slender and spiculiform on the actinal surface, except for a few enlarged ones at outer end of plate.
Raised ridge of inferomarginal plates (at middle of ray) when denuded has the breadth of the actinal face 3 or a little over 3 times the length of the inner end of this ridge, while the outer end (that defining ambitus) is bent slightly distad.	The extreme breadth of the actinal aspect of ridge is about 2 times the length of the inner end, while the outer end is not bent distad.
Actinal intermediate plates very narrow in the interradial region, the interradial dimension at least twice the other, sometimes 3 or 3.5; the fasciolar grooves separating these plates are wide and clearly marked (as wide as denuded tabulum of adjacent plates).	Tabulum of actinal intermediate plate not so compressed, and grooves more or less masked by spinelets. The actinal plates are fewer, but, in proportion to width of inferomarginals are larger.
Central spinelets of actinal intermediate plates decidedly thicker than the peripheral in the interradial region, and somewhat squamiform and appressed.	Central spinelets not thicker than the peripheral, but slender and radiating.
Abactinal plates of lateral regions of area roundish, not strongly lobed.	Abactinal plates of lateral regions of area strongly lobed, those of median radial region slightly scalloped.

DIPSACASTER DIAPHORUS Fisher.

Plate 12, fig. 3; plate 28, fig. 2; plate 29, fig. 2; plate 31, fig. 1; plate 41, figs. 3, 3*a–c*.

Dipsacaster diaphorus FISHER, 1913*a*, p. 622.

Diagnosis.—Similar in form to *D. sladeni*, but differing in having short, thick, clavate, or subterete thorny paxillar spinelets, more numerous adambulacral spinules, a small madreporic body and less conspicuous marginal spinules; all the shorter spines and spinelets thorny; paxillae with 20 to 25 spinelets; furrow spines 8 or 9, very slender, pointed, slightly compressed; subambulacral spinules, 15 to 20 in series or forming a sort of rosettelike group on the convex surface of plate; madreporic body small. Rays rather slender, disk large, interbrachia abruptly rounded. R=31 mm., r=10 mm., R=3 r+; breadth of ray at base, 11.5 mm.

Description.—Paxillar area compact. Paxillae comparatively large, largest laterally at base of ray and adjacent interradial regions of disk; smaller in center of disk. Pedicels rather short, crowned by a capitate group of 20 to 25 thick clavate or cylindrical round-tipped minutely thorny spinelets, about as long as the pedicels, and relatively fewer and thicker than usual in this genus. Abactinal plates relatively large and close-set, those of the disk roundish, with sometimes an indication of lobing, becoming broadly elliptical on the radial line and somewhat four-sided or subelliptical laterally. The papulae are absent from center of disk and midradial line, but this is very likely due to the small size of specimens. In the specimen from station 5423 many of the paxillae have the spinelets closely appressed and with slightly larger tips, resembling a simple pedicellarian apparatus.

Superomarginals 23, abactinal in position, nearly square except in the interbrachia, and covered with slightly spaced spinelets similar to those of the paxillae, though a trifle stouter on the exposed median area of the plate. Fascioles wide and moderately deep. Terminal plate broader than long, saddle-shaped, with a wide, deep notch toward the paxillar area.

Inferomarginals extending laterally beyond the superomarginals and corresponding to them, plate for plate; in width about equaling the length of 2 with intervening fasciole. Plates covered with spaced, appressed, slender, sharp, sometimes flattened and squamiform spinelets, becoming a tuft of longer spinules on the outer end. Two or three of these are larger than the rest, arranged in a transverse series and similar to the lateral spines of *D. sladeni*, though less conspicuous.

Actinal interradial areas only moderately large; the plates in a larger and more mature specimen would probably extend farther along the ray. One series extends to tenth inferomarginal, or a little less than half the length of ray; a second extends to fourth or fifth; and a third extends to the third inferomarginal. An odd interradial series of about 4 plates extends from the pair of plates back of the jaws to the margin. The plates have fairly high ridges crowned by 15 or more slender, very thorny spinelets, larger at the tip than at base, and longer than the inferomarginal spinelets.

Adambulacral plates slightly convex. Furrow spines, 8 or 9, long, slender, tapering, pointed, and slightly compressed, but not forming a wide blade as in the foregoing species, the 3 or 4 median the longest (considerably longer than plate) and the others graduated in length toward either end of series. Subambulacral spinules 15 to 20, much shorter, thorny, thickest at tip, and graduated in length from the curved series of 5 to 7 back of furrow spines to the outer edge of plate where the spinelets are equal and similar to those of actinal intermediate plates. The spinules nearest the furrow series are about two-thirds as long as the furrow spines, and the lateral and outer margins of plate are armed with spinelets, giving the appearance of a rosette on some plates. The subambulacral spinules form about 3 longitudinal series, but often outside the first series a regular arrangement is not discernible.

Mouth plates with a marginal series of 8 or 9 long, slender, marginal spines, in a curved series, similar to the furrow spines, increasing in length toward the inner angle where they are considerably larger than the furrow spines. Suborals on the inner end of plate nearly as long as the marginals, and thence decreasing in length outward until they are subequal to the actinal intermediate spinelets. They are numerous in about 3 series parallel to median suture.

Madreporic body small for the genus, about its own diameter from the margin and overhung by 3 or 4 large paxillae.

Type.—Cat. No. 30530, U.S.N.M.

Type-locality.—Station 5526, between Siquijor and Bohol Islands, Philippine Islands, 805 fathoms, green mud and globigerina, bottom temperature 52.3° F.; 1 specimen.

Distribution.—Sulu Sea, Mindanao Sea, and off northern Samar, 383 to 805 fathoms.

Specimens examined.—Five; the type and 4 from the following stations:

Station 5423, Sulu Sea, near the Cagayanes Islands, 508 fathoms, gray mud, coral sand, bottom temperature 49.8° F.; 1 specimen.

Station 5445, north coast of Samar, 383 fathoms, green mud, bottom temperature 44.3° F.; 2 specimens.

Station 5528, between Siquijor and Bohol Islands, 439 fathoms, globigerina ooze, bottom temperature 53.3° F.; 1 specimen.

Remarks.—The specimens probably are all immature, although the type has the gonads developed, making the generic determination certain. The examples from station 5445 are small, and, owing to the lack of development of the papulae and the low paxillae, resemble narrow-rayed *Patagiaster*. It would be difficult to distinguish the young of these 2 genera, since the distinction depends upon the distribution of gonads and papulae.

This species is similar to *D. sladeni* in general habit, but the paxillae are composed of thorny clavate spinelets which can not by any stretch of the imagination be called "capillary." They are stouter in proportion to length than in any other oriental species. The marginal spines are not so well developed, and even though the specimens are small the adambulacral plates have 8 or 9 furrow spines and upward of 20 subambulacral spinules. The madreporic body is rather small.

Genus PATAGIASTER Fisher.

Patagiaster Fisher, 1906, p. 1029. Type, *P. nuttingi* Fisher.

PATAGIASTER SPHAERIOPLAX Fisher.

Plate 28, fig. 3; plate 29, fig. 3; plate 41, figs. 4, 4*a*.

Patagiaster sphaerioplax Fisher, 1913*a*, p. 623.

Diagnosis.—Differing from *P. nuttingi* in having shorter, broader rays, larger paxillae with more numerous granules; in having the paxillae in a definite radial, and parallel longitudinal series; in having broader marginal plates and slenderer actinal spinulation. R=28 mm., R=12 mm., R=2.3 r; breadth of ray at base, 13.5 mm. Disk large, rays short, tapering from wide, rounded interbrachia to a pointed extremity; general form depressed; sides of ray rather thin, rounded.

Description.—Paxillar area very compact, the paxillae crowded and large. The smallest paxillae are on the central portion of disk, in a circle with a radius of about one-half r; they increase rapidly in size and are largest on the peripheral interradial regions and proximal radial areas, decreasing slightly in size toward the end of ray. A regular radial series is clearly discernible, the others being arranged parallel to this, as in *Pseudarchaster* and many other Goniasteridae. In a transverse line across the base of the ray 13 to 15 of these series can be counted. Three series reach the end of the ray. The larger paxillae have a convex flaring crown with about 30 to 40 elongate regular beadlike granules, surrounded by a peripheral series of numerous, slender, short spinelets, some of which are intermediate in form with the central granules. As compared with *P. nuttingi*, the paxillae of *sphaerioplax* are larger, not only comparatively but actually, especially on the rays, and there is a smaller area of small paxillae on the disk. The median radial series of paxillae is not easily distinguishable in *nuttingi*, as the radial paxillae generally are smaller than the lateral, and not very regularly arranged. In *nuttingi* there are over 20 poorly defined longitudinal series, as the paxillae arrange themselves more readily in oblique transverse series. Such an arrangement in oblique series is observable in *sphaerioplax*, in addition to the longitudinal series. Finally, the paxillae of *sphaerioplax* contain many more granules than those of *nuttingi*.

Superomarginal plates 19, encroaching conspicuously upon abactinal area, rather wide in the interbrachia and decreasing regularly and rapidly in width toward end of ray. The width of the first plate equals the length of 3 measured at the outer end, while at the tip the width only slightly exceeds the length. The plates form a slight bevel, and the rounded upper edge of the ray is near the outer end of the plate. The plates are covered with beadlike granules and a peripheral series of slender spinelets, becoming capillary in the deep, narrow, fasciolar grooves. Terminal plate ovoid, granulate.

Inferomarginals corresponding to superomarginals and extending very slightly beyond them laterally, a longitudinal fasciolar furrow separating the 2 series. They encroach upon the actinal surface about as much as do the superomarginals upon the abactinal, but their lateral surface is slightly more extensive, so that the extreme width of the plates exceeds slightly that of superomarginals. The plates are covered with slender, papilliform, slightly appressed spinelets, and in addition proximally 3, then 2, and distally 1 slender, lanceolate, appressed spinules in the median transverse line. The armature is similar to that of *P. nuttingi*, but the spinelets and enlarged spinules are slenderer and the latter are a little smaller. The interbrachial plates of both series in *nuttingi* are a trifle narrower and the inferomarginals project a little more laterally.

Actinal interradial areas extensive; intermediate plates extending in a single series half the length of furrow (to sixth inferomarginal) and in 2 series a little over a third the furrow (to third inferomarginal). The odd interradial series has 4 plates, and extends from a pair of plates back of the jaws to the interradial suture between the 2 first inferomarginals (as in *P. nuttingi*). The plates have a conspicuous keel and carry a paxilliform group of 15 to 18 slender, rather long spinelets, those in center the stoutest and prickly at the slightly expanded tips. The spinelets are slenderer and longer than in *P. nuttingi*.

Furrow spines slender, pointed, slightly compressed, in a regular comb of 6, sometimes 7, the contour of the distal margin being curved. Subambulacral spines, 12 to 16, slender, terete, with prickly tips, 3 or 4 along either lateral margin being the smallest, and a series of 3 or 4 back of the furrow, nearly as long as the furrow spines. Three longitudinal series can usually be discerned, the spinelets in the outermost series being similar to those of the actinal intermediate plates.

Mouth plates rather narrow, forming a salient inner angle. Marginal spines about 9, gradually increasing in size toward the inner teeth, which are flattened and bladelike, the outer members being compressed and similar to adambulacral furrow spines. The series is continued along the lateral margin in 8 or 10 short terete pointed spinelets. Suborals similar to the subambulacrals, 15 to 18 in number, in 2 series, one along the median suture and the other intermediate and parallel to the outer margin but not reaching the inner end of the plate.

Madreporic body small, wholly concealed, a little nearer marginal plate than center of disk and nearly in the middle of r.

Tube feet with a conical button at tip.

Type.—Cat. No. 30531, U.S.N.M.

Type-locality.—Station 5178, vicinity of Romblon Island, Philippine Islands (lat. 12° 43′ N.; long. 122° 06′ 15″ E.), 78 fathoms, fine sand; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This is a well-marked species of *Patagiaster*, differing from the type *P. nuttingi* of the Hawaiian Islands in having shorter rays, larger paxillae with much more numerous granules, in having the paxillae arranged in very definite longitudinal series parallel to the radial series, which, with the adradial paxillae, are subequal to the lateral plates, not smaller and irregularly arranged. The marginal plates are broader in *sphaerioplax* and the actinal spinulation more delicate.

This genus was established for a single species, but the group is a well-marked one, for in addition to *nuttingi* and *sphaerioplax*, I have examined a third species dredged by the *Albatross* in Japan. The resemblance between this Japanese species and *Pseudarchaster* is very striking, as indeed is that of *sphaerioplax*. But the pointed tube feet, concealed madreporic body, and the character of the furrow comb are all different, the first character being the fundamental one which places *Patagiaster* in the *Astropectinidae*. Although the new species is less like *Dipsacaster* than is *P. nuttingi*, I still believe that the relationship is rather close.

Patagiaster differs from *Dipsacaster* in having the gonads confined to the interradial regions, not festooned along the ray, in lacking papulae on the midradial region and center of disk, and in having the paxillar spinelets more granuliform, although this last character is partly bridged by *Dipsacaster diaphorus*. It differs from

Plutonaster in having an odd interradial series of actinal intermediate plates, and a different type of marginal armature; from *Tethyaster* in having the gonads confined to the interradii, and a less angular and less astropectenoid type of adambulacral armature. From *Leptychaster*, to which it is closely related, *Patagiaster* differs in having armed inferomarginals and a less angular and longer comb of furrow spines, as well as a truly concealed madreporic body. In *Leptychaster* the testes are serially arranged along either side of the ray, while the ovaries are strictly interradial and in a single tuft on either side of the interradial septum.

Genus KOREMASTER Fisher.

Koremaster (subgenus) FISHER, 1913*a*, p. 623. Type, *Dytaster* (*Koremaster*) *evaulus* Fisher.

Diagnosis.—Differs from typical *Dytaster* in having a very weak abactinal integument, Astropectenlike paxillae with well-developed pedicels and relatively long, slender spinelets; and in having the marginal fascioles well developed. Pedicellariae, marginal armature, and adambulacral armature, gonads, and alimentary system as in *Dytaster*. An odd interradial series of actinal intermediate plates, often irregular, is present, and the madreporic body is smaller and less densely covered with paxillae than in *Dytaster*.

KOREMASTER EVAULUS (Fisher).

Plate 33, fig. 2; plate 34, fig. 2; plate 40, figs. 2, 2*a*–*e*.

Dytaster (*Koremaster*) *evaulus* FISHER, 1913*a*, p. 623.

Diagnosis.—Rays 5. R=62 mm., r=15.5 mm., R=4 r; breadth of ray at interbrachium 19 mm., at tenth superomarginal 9 mm.; interbrachium arcuate or rounded-angular; rays arcuately tapering and narrow beyond the basal fourth; abactinal integument inflated; paxillae well developed, often penicillate, with fairly tall pedicels and slender, pointed, thorny spinelets; abactinal, globose pedicellariae; well-developed marginal fascioles; marginal plates small, blocklike, with a stout conical spine; actinal intermediate pedicellariae; furrow spines much compressed, 7 or 8; subambulacral spines, 6 to 10, 1 being enlarged; usually 1 or 2 subambulacral pedicellariae; first adambulacral plate compressed; marginal mouth spines much compressed.

Description.—Abactinal integument rather thin, inflated. Paxillae fairly uniform, not crowded, with well-developed pedicels on disk and proximal half of ray, becoming low and *Dytaster*-like on the outer part. Largest paxillae are on the madreporic body, but aside from these the next largest are found in the interradial regions and adjacent portion of the proximal half of ray, the smallest paxillae being on center of disk, midradial line, and distal half of ray. The difference in size is not great until the outer third of ray is reached. The spinelets are slender, tapering, and pointed, and are slightly shorter to slightly longer than height of pedicel, the latter being the variable feature. Usually they are borne in a brushlike tuft, but sometimes radiate apart. A large paxilla has 15 to 20 spinelets, of which 3 to 5 stand on the convex top of the pedicel and the others, with a slight basal web, form a peripheral series. The distinction between the two sets is not sharp. When dried, the spinelets are glassy in appearance and minutely thorny; and the paxillae resemble, on a small scale, those of *Crossaster papposus.*

Scattered over the paxillar area and occurring rather commonly around the border, are lower paxillae bearing globose pedicellariae composed of 3 to 5 scalelike granules, or very low, broad, convex squamiform papillae. The pedicellaria resembles a large globular granule split nicely into 3 to 5 sections.

Abactinal plates of ray have a generally broadly elliptical outline, but are irregular and often indented or scalloped. They are spaced, except at end of ray and center of disk. Papulae, 4 to 6 about each plate, absent from end of ray and center of disk.

Marginal plates rather small, regular, opposite, and square, as seen from side, and forming a perpendicular lateral face to ray. They are separated by pronounced and abrupt, vertical fascioles, lined with delicate spinelets. Superomarginals, 37 to the ray, encroach very slightly upon the paxillar area, and, as seen from above, are of about the same width throughout the series, this equaling about one-half the height of the plates proximally, while distally the height gradually lessens and becomes equal to the width. The plates form an evenly rounded edge to the dorsal surface, and each bears on this rounded margin between the dorsal and lateral faces an erect, stout, conical, sharp spine 3 mm. long proximally (or equal to 2 plates in length). Sometimes the spine is shorter. The spinelets covering the plate are very similar to the paxillar spinelets, delicate, tapering, or slightly swollen and sharp; and when dried they are thorny, as are all the spines and spinelets.

Inferomarginal plates encroach conspicuously upon actinal surface, the actinal facet of the plate being wider than the lateral in the interbrachium and about equal on distal half of ray. The covering of the plates is similar to that of the superomarginals, and similarly on the angle between the actinal and lateral facets of plate is a conical sharp spine subequal to or proximally a trifle larger than the corresponding superomarginal spine, the series being very regular, and the length decreasing toward the extremity of ray.

Terminal plate as seen from above broadly arrow-shaped with a deep indentation equal to half its length on the proximal side and bearing on the rounded tip a stout, sharp central spine with one on either side, and between them numerous accessory sharp, slender spinules.

Actinal interradial areas large, but owing to the narrowness of rays the plates do not extend beyond the eighth inferomarginal, or about a fourth the length of ray measured along side. They are arranged in not very regular series extending from the adambulacrals to margin, toward which the plates diminish in size. There is an odd interradial series. The plates are externally irregularly polygonal to roundish, with a central eminence crowned by a conspicuous low pedicellaria, similar in structure to those of the abactinal surface, but much larger, and composed of from 4 to 8 low, broad, swollen, blunt papillae, surrounded by a circle of several slender spinelets. The pedicellaria resembles, in miniature, the bud of a flower with fleshy petals, except 1 or 2 near the mouth plates, which are pectinate. On the ray the pedicellariae have sometimes slightly longer jaws. The figure will better show the form. Here and there are plates without pedicellariae, capped by a group of divergent slender spinelets. In the small specimen from station 5601 the pedicellariae are much fewer.

Adambulacral plates narrow, being much longer than wide, with a rounded furrow margin bearing 7 or 8 fairly long, bluntly pointed, compressed spines, widened and bladelike at the base, and sometimes rather abruptly constricted near the tip, the median spines being slightly the longest and all forming a vertical comb. Close to these on the surface of the plate is an irregular longitudinal series of 6 to 10 cylindrical, pointed spines, of which 1, near center, is much enlarged and subequal to the furrow spines or sometimes longer, while the rest are graduated in size toward either end. But on the outer part of the ray the other spines are abruptly smaller, one-half to two-thirds the length of the larger, and not clearly arranged in a series. Most of the plates bear a prominent pedicellaria with usually 3 jaws (slightly longer than those of interradii) and usually situated at the aboral end of plate. Many plates bear a second pedicellaria, sometimes slightly smaller than the other, near the middle or the adoral end. The specimen from station 5601 seldom has an adambulacral pedicellaria and the number of subambulacral spines is therefore greater (8 to 12). The furrow spines are not widened at the base; perhaps this is an attribute of age. First adambulacral plate somewhat triangular and compressed.

Mouth plates convex actinally, the combined pair projecting into actinostome for half their length, and broader at outer than at inner end. Furrow spines 7, the inner heavy and compressed, and much larger than the adambulacral furrow spines. They are broken in the type, but they decrease in size toward the first adambulacral.

and the series is continued along the adambulacral margin by a number of smaller, cylindrical, pointed spines. Numerous similar spines cover the surface of the plates forming 2 or 3 irregular series.

Madreporic body 5 mm. in diameter, or one-third minor radius, and situated less than its own diameter from margin of paxillar area. Fine, irregular striae proceed from near the center. About 15 paxillae spring from the surface.

Color in alcohol, bleached yellowish.

Tube feet rather large, pointed, but with a small conical knob at the tip; no deposits.

Type.—Cat. No. 30532, U.S.N.M.

Type-locality.—Station 5606, Gulf of Tomini, Celebes, 834 fathoms, green mud.

Distribution.—Known only from Gulf of Tomini, Celebes.

Specimens examined.—The type and a specimen from station 5601, Gulf of Tomini, Celebes, sand, globigerina, and pteropods.

Remarks.—This species is remarkable for the typical paxillae and well-developed marginal fascioles. Among the species of *Dytaster* dredged by the *Challenger* it shows most resemblance to *D. spinosus*, but has perpendicular sides to the ray, taller and more penicillate paxillae, and characteristic pedicellariae. *D. aequivocus* Sladen is a very immature form from the Arafura Sea, west of the Aru Islands, 800 fathoms. On this account it can not be compared with *Koremaster evaulus*.

The genus "*Crenaster*" of Perrier is based on the absence of actinal intermediate and abactinal pedicellariae, on the smaller number of actinal intermediate plates, and on the presence of an enlarged subambulacral spine. Yet in the descriptions of *Crenaster mollis* and *C. spinulosus* no mention is made of this enlarged spine. In *Dytaster grandis* the enlarged subambulacral is present on the outer part of the ray and there are abundant pedicellariae. Both forms of *Koremaster* have the enlarged subambulacral spines plus pedicellariae. The distinction based on less numerous actinal intermediate plates does not hold. In so far as "*Crenaster*" rests on these characters it is not a workable group.

Koremaster differs greatly in appearance from typical *Dytaster*, such as *nobilis* and *grandis* (=*madreporifer* Sladen). The paxillae are higher, with long spinelets, and are more like those of *Astropecten;* the marginal plates, at least proximally, have well-developed fascioles, and are therefore thicker than in typical *Dytaster;* the actinal intermediate plates are more convex and paxilliform, while an irregular odd interradial series of plates is present. In typical *Dytaster* this character is apparently variable, but exact data are lacking in some species. The odd series is present in *gilberti*, but absent apparent in *nobilis* and *exilis;* in *grandis* it seems to be variable, but the plates are usually irregular, so that it is hard to trace the series. In *gilberti* the paxillae are fairly high, though the spinelets are short, and at the base of the ray the marginal plates are separated by fascioles, less well developed than in *Koremaster*.

KOREMASTER EVAULUS SPICULATUS, new subspecies.

Plate 33, fig. 1; plate 34, fig. 1; plate 40, figs. 3, 3*a–f*.

Diagnosis.—Very close to the type-species, but differing in having more elongate and conical pedicellariae with less modified jaws, fewer pedicellariae, terete furrow spines, slightly wider mouth plates, and less compressed first adambulacral plates. R=44 mm., r=12 mm., R=3.66 r. General form slightly variable, the rays either tapering directly from abruptly rounded interbrachial angle, or arcuately, the interbrachium being open and rounded.

Description.—Abactinal surface and paxillae very similar to those of the type, but the pedicellariae are either few or entirely absent. They seem to occur only around the edge of the paxillar area next to the marginal plates, and they have the much slenderer and proportionately higher jaws less modified. In some pedicellariae the jaws are very nearly like short sharp spines, such as occur on paxillae.

Abactinal plates irregularly elliptical on rays to subcircular at center of disk, where they are close together, but spaced on the rays; 4 or 5 papulae about each plate; the papulae are absent from end of ray and center of disk; abactinal integument thin and flexible.

Marginal plates in proportions and armature practically like those of *evaulus*. One specimen only has a second much shorter accessory spinule on the inner edge of most of the superomarginal plates. Superomarginals 30 in type. Terminal plate shorter and blunter than in *evaulus*, being only a little longer than wide, but is nevertheless variable. Some approach very close to *evaulus*. Inferomarginals rarely with 2 spines side by side.

Actinal intermediate plates extending to about the tenth or eleventh inferomarginal or nearly half the ray—proportionately farther than in *evaulus*. The odd interradial series is sometimes not so evident as in *evaulus*, owing to its having been crowded to one side, but usually it is perfectly plain. The plates are either wholly without pedicellariae or with a variable number. These have 3 to 5 spiniform jaws, which are less modified than in *evaulus*. They vary in form from unmodified spines to elongate curved spatulate swollen papillae. Only in one specimen do they approach closely those of *evaulus*, but this specimen also has pedicellariae with the elongate spiniform type of jaw. A comparison of figures will best illustrate the difference. (Pl. 40, fig. 3c.) Besides the pedicellariae the plates bear upward of 10 slender spinelets.

Adambulacral armature: Furrow spines 6 or 7, long, fairly slender, terete, and sharp, and when dry minutely thorny. They show no sign of the compression characteristic of *ecaulus*, and they usually extend in a fanlike series horizontally across the furrow, being nearly equal, except that either or both laterals may be shorter and slenderer, especially when there are 7 spines to the series. Subambulacral spines usually in 2 series. In the first are 5 to 8, of which 1 near the center is enlarged and nearly or quite as large as the median furrow spines; the rest are either successively shorter as at the base of ray or abruptly shorter. The outer series consists of 5 to 8 spinelets similar to those of the actinal intermediate plates. Along either transverse margin of plate are 2 or 3 spinelets belonging to the above series, with sometimes 1 or 2 added. On the outer half or third of the ray the enlarged subambulacral spine is considerably longer and stouter than the furrow spines, for the reason that it remains nearly uniform in size while the furrow spines rapidly shorten. Subambulacral pedicellariae are so rare as to be a negligible character. The first adambulacral plate is not compressed, though a little wider than the succeeding.

Mouth plates broad and convex, a trifle broader in proportion to length than in *ecaulus*. Marginal spines 6 to 8, terete, tapering, pointed, the inner about half as long as the plate, the rest successively shorter. Suboral spines numerous and smaller, in a well-defined series of 8 to 10 along the edge of the median suture, decreasing in length from the teeth outward, and in about 2 irregular intermediate series. The marginal series, as in *ecaulus*, is continued by smaller spines along the adambulacral margin.

Madreporic body large, less than its own diameter from margin, and with about 12 paxillae on the surface. One of them is very much larger than the rest, this difference not being evident in the type of *ecaulus*, though indicated in a less extreme form in the small specimen from station 3601.

Anatomical notes.—Stomach large, and not divided into dorsal and ventral divisions; hepatic coeca short, extending only about one-fifth the length of ray; intestinal coecum small and in the form of a simple ovoid sac; anal aperture small. Gonads not confined to interradius, but in the form of a series of several independent tufts, diminishing rapidly in size distad and reaching nearly to the middle of ray. Polian vesicle in each interradius except that of stone canal; ampullae large, 2-parted. Superambulacral plates very small, wanting opposite the first, and either very rudimentary or absent opposite the second ambulacral plates.

Type.—Cat. No. 37013, U.S.N.M.

Type-locality.—Station 5332, Mindoro Strait, west of Mindoro, Philippine Islands, 745 fathoms, green mud, bottom temperature 38.2° F.

Distribution.—Known only from the type-locality.

Specimens examined.—Seven, from the type-locality.

Remarks.—This form resembles so closely *craulus* that it has been described as a geographical race, although no specimens from intermediate localities have been examined. The differences are mainly as follows: *craulus* has fewer and higher pedicellariae with less modified jaws, and they are not found on the adambulacral plates; the rays are a little shorter and the disk relatively a little larger; the actinal intermediate plates extend farther along the ray; the furrow spines and marginal mouth spines are terete, not markedly compressed; the subambulacral spines are in 2 series, but this is sometimes the case in the foregoing species.

Family LUIDIIDAE Verrill.

Genus LUIDIA Forbes.

Luidia FORBES, Mem. Wernerian Nat. Hist. Soc., vol. 8, 1839, p. 123. Type, *L. fragilissima* (=*L. ciliaris* (Philippi)).

KEY TO THE SPECIES OF LUIDIA HEREIN DESCRIBED.

*a*¹. Rays 5, and paxillae never with a conspicuous central spine.
  *b*¹. Inferomarginals with a single conspicuous lateral spine and several short, appressed actinal spinules.
    *c*¹. Adambulacral armature: a furrow spine, a large subambulacral spine, and adorad to this, a long, slender, two-jawed pedicellaria. *longispina*, p. 164.
    *c*². Adambulacral armature: a furrow spine and, proximally, 5 subambulacral spines; distally, 3; no adambulacral pedicellariae. *prionota*, p. 164.
  *b*². Two or 3 conspicuous spines (sometimes 4 or 5) in a transverse series on inferomarginal plate; similar in general appearance to *L. sarsi*------ *orientalis*, p. 166.
*a*². Rays 7 to 11.
  *b*¹. Paxillae without a conspicuous central spine, or if this is present then only on outer part of ray.
    *c*¹. Rays usually 8; paxillae of lateral rows quadrate or roundish quadrate, compact, without a conspicuous pedicellaria; no large naked spaces between the inferomarginal plates; never any pedicellariae in furrow--- *maculata*, p. 168.
    *c*². Rays constantly 11; paxillae spaced, delicate, with a conspicuous central pedicellaria and also several on the sides of the pedicels; inferomarginals separated actinally by large, naked spaces; a few proximal adambulacral plates with a slender pedicellaria just dorsal to furrow spine--*gymnochora*, p. 175.
  *b*². Some of the paxillae of lateral parts of ray, at least, with conspicuous central spine.
    *c*¹. No pedicellaria just dorsal to furrow spine.
      *d*¹. Rays 7 (sometimes as few as 5); inferomarginal spines usually 3, in a transverse series------------------------------ *savignyi*, p. 170.

d^2. Rays 8 to 10; inferomarginal spines usually 4 to 6, sometimes only 3 in small specimens ________________ *aspera*, p. 171.

c^2. A small two-jawed pedicellaria just dorsal to the furrow spine; rays 10 ________________ *avicularia*, p. 172.

LUIDIA LONGISPINA Sladen.

Plate 43, fig. 5.

Luidia longispina SLADEN, 1889, p. 254, pl. 43, figs. 3 and 4; pl. 45, figs. 3 and 4.

Two specimens are larger than Sladen's type. The larger has the following dimensions: R=74 mm., r=10.5 mm., R=7 r. The specimens agree with Sladen's description. There is a fifth regular series of abactinal paxillae. The paxillae, as noted by Sladen, are distinctly spaced except along the median area of ray.

Type.—In British Museum.

Type-locality.—*Challenger* station 203, east of Panay Island, Philippine Group, 20 fathoms, mud.

Distribution.—Philippine Islands, from Samar and Panay to Tawi Tawi; 18 to 24 fathoms, mud or fine sand.

Specimens examined.—Five specimens from the following Philippine stations:

Station 5157, 3.3 miles northeast Tinakta Island, Tawi Tawi Group, Sulu Archipelago, 18 fathoms, fine sand; surface temperature, 79°; 1 small specimen.

Station 5182, off eastern Panay (3.7 miles southeast Antonia Island), 24 fathoms, fine sand, mud; surface temperature, 80°; 3 specimens (1 very young).

Station 5209, off western Samar (1.8 miles northeast Taratara Island), 20 fathoms, green mud; surface temperature, 84°; 1 specimen.

LUIDIA PRIONOTA Fisher.

Plate 41, figs. 5, 5*a*; plate 45, figs. 1, 2.

Luidia prionota FISHER, 1913*c*, p. 202.

Diagnosis.—Similar in general form to *Luidia forficifera* Sladen, but differing in lacking entirely adambulacral pedicellariae, in having proximally at least 5 adambulacral spines in addition to the curved furrow spine, the 4 outer forming 2 longitudinally oriented pairs; central spinelets of paxillae not granuliform; marginal spine usually longer than extreme width of inferomarginal plate; actinal intermediate pedicellariae usually absent. Rays 5. R=32 mm., r=5 mm., R=6 r; breadth of ray at base, 6 mm. Abactinal surface slightly arched, usually plane on radial region of ray; inferomarginals slightly arched, forming a broad border to actinal surface; marginal spines fairly long, single, forming a prominent fringe to ambitus.

Description.—Paxillae arranged as in *L. forficifera*, there being 3 regular series of fairly large, subquadrate ones, with a fourth and even a fifth series of smaller paxillae distinguishable. The paxillae are slightly spaced, the larger having upward of 15 to 20 peripheral, slender spinelets, and 10 or 12 stouter and shorter central spinelets, which are longer and less granuliform than in *forficifera*. The smaller paxillae vary greatly according to their position, an average median paxilla having upward of 12 peripheral and 7 or more central spinelets. The dorsal surface differs from that of *L. forficifera* chiefly in the longer central spinelets of the paxillae. The dorsolateral paxillae are about intermediate between the quadrate and rotund forms. In a specimen from station 5158 the central spinelets are little if any stouter than the peripheral.

The type of inferomarginal armature resembles that of *L. forficifera*, but the lateral spine is longer, usually exceeding the width of the plate, except at the very base of the ray where it about equals the width. The spine is flattened, narrow, and pointed. Between the base of the spine and the inner end of plate is a straight series of about 4 (3 to 5) short, lanceolate spinules; or there may be a second series of about 3 spinules adorad to the above, as in *forficifera;* occasionally the spinules form a zigzag series. A series of very delicate spinelets fringes either transverse border of the plate, and they are not swollen at the inner end of the plate as in *forficifera*. The marginal fascioles are fairly deep and about as wide or a little wider than the thickness of the intervening ridges.

Adambulacral armature: (1) A rather long, curved, compressed furrow spine (about equaling 1.5 times the width of plate), followed by a stouter, slightly longer, pointed spine, slightly curved at the base. (2) Just external to this, side by side, are 2 stout unequal tapering pointed spines, the aboral often the larger and usually a little shorter than the foregoing. (3) These are followed by another pair of smaller spines, of which the aboral is usually the larger—standing also in a longitudinal series with reference to ray. Beyond the base of the ray these spines are usually absent. (4) On the first 2 or 3 plates 1 or 2 small spinules stand behind the second pair of spines. On the outer part of the ray there are present only 4 spines, namely, the furrow, the inner subambulacral, and the first pair of spines (No. 2 above). There is no subambulacral pedicellaria as in *forficifera*, the adoral spine in the first pair occupying its position. The second pair of spines is present in a very few proximal plates in *forficifera*.

Proximally the actinal intermediate plates bear a very few delicate, short, spinelets, which decrease to 1, and finally disappear on the distal half of ray. The 2 interradial plates bear a tuft of spinelets. Two specimens without locality have two-jawed tapering pedicellariae on the interradial plates (in one of them, not on all). The other specimens entirely lack pedicellariae, such as are present in *forficifera.*

The mouth plates form a salient angle into actinostome, and at the inner end of each pair of plates are 2 large two-jawed pedicellariae half as long as the interradial width of the plate and extending side by side horizontally over actinostome. Seen from the actinal surface they are slightly tapering, bluntly pointed. Six to eight sharp spines occupy the outer margin between the pedicellaria and outer end of plate, and about the same number, close to the above, follow the margin of the narrow median suture.

Type.—Cat. No. 32622, U.S.N.M.

Type-locality.—Station 5181, off eastern Panay (6.6 miles northeast Antonia Island), 26 fathoms, mud and fine sand, surface temperature 80° F.; 6 specimens (4 young).

Distribution.—Panay to Tawi Tawi Group, 12 to 26 fathoms.

Specimens examined.—Nine—6 from the type-locality, 2 without locality, and 1 from station 5158, 1.9 miles southeast of Tinakta Island, Tawi Tawi Group, Sulu Archipelago, 12 fathoms, coarse sand, shells.

Remarks.—*L. prionota*, on account of the absence of adambulacral pedicellariae and the large number of adambulacral spines proximally can not be confused with *L. forficifera* or *L. quinaria* (including *L. limbata*). It differs from *L. penangensis* de Loriol, which has constantly 6 rays, and a prominent madreporic body, in having larger paxillae, in lacking adambulacral pedicellariae, and in having more than 3 adambulacral spines. *Luidia chefuensis* Grube is apparently a museum name only. According to Sladen (1889, p. 253) it has not been described. This form is said by Sladen to have a comb of 4 or more spinelets, running parallel to the furrow, behind 2 single curved spinelets, apparently in the position occupied by the inner pair of spines of *prionota.*

The absence of adambulacral and abactinal pedicellariae suggests *Luidia clathrata* of the West Indies and southern United States, and *L. foliolata* (southern Alaska to Mexico).

LUIDIA ORIENTALIS Fisher.

Plate 43, figs. 2–4; plate 44, fig. 1; plate 46, fig. 3.

Luidia orientalis FISHER, 1913*c*, p. 203.

Diagnosis.—Related to *L. sarsi* Düben and Koren, *L. africana* Sladen, and *L. asthenosoma* Fisher. Closely resembling *L. asthenosoma*, from which it differs in having deeper and broader marginal fascioles, slightly longer inferomarginal and adambulacral spines, longer inferomarginal spinelets, and actinal intermediate pedicellariae tapering slightly when seen from side (untapered or obovate in *asthenosoma*). Rays 5. R=about 120 mm., r=about 14 mm. The tip of ray is regenerating, so that the original was considerably longer. Breadth of ray at base, 15 mm.

Description.—The paxillae greatly resemble those of *L. asthenosoma*, having longer and slenderer spinelets than are present in *sarsi*, even a little longer than in *africana*. The small paxillae of median portion of ray have slender pedicels, which usually are broader at the top and bear 1 to 4 or 5 central and 8 to 12 peripheral, thorny, sharp spinelets about three-fourths the length of the pedicel. The crest of the superomarginal paxillae is crescentiform, with the concavity abutting on the upper end of the inferomarginal. Each paxilla bears 20 to 30 long, slender spinelets. There are about 2 regular series of paxillae parallel to the superomarginal, of which 3 correspond to 5.5 of the dorsolateral. Rarely an obovate two-jawed pedicellaria is present on one of the small median paxillae. These are usually numerous in *asthenosoma*.

The inferomarginals have slightly higher special ridges separated by broader fasciolar furrows than in *sarsi* and *asthenosoma*, and the ridges are slightly thinner in proportion to the extreme width of the plate. In *orientalis* the furrow in width equals 1.5 times the thickness of the ridge, while in *asthenosoma* the two are very nearly equal. The inferomarginal plates bear on the outer half 2 stout, long, sharp, subterete spines, the upper usually the longer and equaling 3 plates in length. A third, considerably shorter spine is usually present, spaced from the lower lateral spine, and at the base of ray is a fourth still smaller, accompanied by several slender, accessory spinules. One of these may occasionally form a fifth spine. On the outer part of ray there are usually 3 subterete, sharp, equidistant spines, graduated in length toward the outer, or 2 lateral and 2 considerably smaller (perhaps only half the length of the outer) on the inner half of plate. The spaced superficial spinelets are long and slender, longer than in *sarsi* or *asthenosoma*, and reaching nearly across the intervening furrows.

Actinal intermediate plates broader than long, with a rounded inner end overlapping broadly the adambulacral plates. The plates bear 1 to 3 spinules on a boss near the inner end, and spaced from these a pedicellaria with 2 broadly spatulate jaws. (See fig. 3, pl. 46.)

The adambulacral armature is of the type of *sarsi* and *asthenosoma*, consisting of a transverse series of 3 long spines, the outer 2 terete, tapering, and subequal, or the median slightly longer, and two-thirds the length of the longest lateral spine. Just adorad to the 2 outer spines are usually 2 unequal spinules. In *asthenosoma* the spines are practically the same but a little shorter.

Mouth plates and armature practically the same as in *L. asthenosoma*, but the median suture broader. (Fisher, 1911*d*, pl. 21, fig. 1.)

Color in alcohol, bleached yellowish brown.

Type.—Cat. No. 32623, U.S.N.M.

Type-locality.—Station 5301, China Sea, vicinity of Hongkong (lat. 20° 37′ N.; long. 115° 43′ E.), 208 fathoms, gray mud, sand, bottom temperature 50.5° F.

Distribution.—Known only from the type-locality.

Remarks.—This species, as stated in the diagnosis, resembles most nearly *L. asthenosoma*, from off the coast of California, to which it is very closely related. It is also related to *L. sarsi*, *L. elegans*, and *L. africana*. It differs from *L. sarsi* in having longer paxillar, marginal, and actinal spines, broader and deeper marginal furrows; it differs from *elegans* in practically the same respects, and in lacking the numerous abactinal pedicellariae of *elegans*. *L. elegans* and *L. sarsi* are very close, probably but races of the same species. It differs from *L. africana*, which represents *elegans* on the east side of the Atlantic, in having broader inferomarginal fascioles, longer inferomarginal spinelets, more tapered actinal pedicellariae, and agrees with it as well as with *asthenosoma* in having longer rays than *sarsi*.

As *L. asthenosoma* is not known north of central California, its range is widely separated from that of *orientalis*. *L. africana*, the nearest form to the westward, is found in the Atlantic off northern Africa. It would appear, therefore, that *L. orientalis* is isolated from its two nearest relatives. *L. sarsi*, *L. elegans*, *L. africana*, *L. asthenosoma*, and *L. orientalis* all bear a rather close resemblance, and the differences which separate the species are less trenchant perhaps than are usually relied upon to separate species of starfishes. The range of variation, so far as known, is slighter than in most species of starfishes, so that the characters, even if relatively slight, are apparently constant and trustworthy. The range of variation is unknown in *L. orientalis*, since there is only one specimen known.

LUIDIA MACULATA Müller and Troschel.

Luidia maculata MÜLLER and TROSCHEL, 1842, p. 77 (Japan). For description and bibliography see: Perrier, 1875, p. 338; Koehler, 1895, p. 387; 1910*b*, p. 267.

Notes on Philippine specimens.—The two nearly equal-sized specimens from station 5346, Palawan, 8 fathoms, present some points of difference when compared with a presumably typical, large example from Misaki, Japan. The Palawan specimens have R=135 to 140 mm., although some of the 8 rays are shorter than this, having been broken and subsequently regenerated. In the Japanese specimen, R=175 mm.; rays 8. The paxillae of the Palawan specimens are distinctly smaller, and not rectangular as are those of the Japanese example, and are evidently similar to those of a specimen from Batavia, described by Perrier (1875, p. 339). The paxillae form 5 or 6 regular series in either side of the ray, but present a more open appearance, due to their much fewer than normal number of spinelets and to the rounded corners of the crowns. A large paxilla at the base of the ray has a circular or broadly elliptical contour to the strongly convex crown, which consists of 12 to 18 unequal, blunt, peripheral spinelets, and 7 to 12 shorter, stouter, subtruncate, spaced, divergent central spinelets. The stoutest commonly stands in the center surrounded by a circle of 6, these in turn surrounded by a partial cycle of slenderer spinelets, intermediate in robustness between the central and the outermost. A considerable but variable number of the superomarginal paxillae, as well as a less number in the next series adjacent, have 1 or 2 pedicellariae with 2 tapering jaws varying from a trifle stouter and longer to a trifle shorter than the spinelets. In the Japanese specimen the paxillae have upward of 25 central and 25 or 30 much slenderer peripheral spinelets, while the crowns are squarish or transversely oblong, and rather close-set. The superomarginal paxillae are nearly square, and a variable number have an inconspicuous 2- or 3-jawed spiniform pedicellaria, usually on the outer longitudinal margin. I do not think this has been mentioned in current descriptions.

The adambulacral armature consists of a curved, strongly compressed furrow spine followed by a much longer, tapering, slightly compressed spine. This in turn is followed by 2 (sometimes 3) large pedicellariae with 3 long, slender jaws, more than one-half, sometimes two-thirds the length of the subambulacral spine. The outer pedicellaria is situated, as a rule, upon an actinal intermediate plate, of which a single series is interpolated between the inferomarginal and adambulacral plates. Rarely, at the base of the ray there are 3 adambulacral spines, the outermost much smaller than the principal spine. In addition there are several small spinelets along the transverse margins of the plate. Koehler (1910*b*, p. 267) records 3 or 4 adambulacral spines on 2 specimens from Aru, and from 1 to 3 pedicellariae. The Misaki specimen alluded to above has 2 adambulacral spines (rarely 3), followed by 3 or 4 conspicuous pedicellariae. The number of adambulacral spines is therefore variable. The pedicellariae of the Palawan specimens are narrower at the base, consequently longer in proportion to width than are those of the Misaki specimens.

The number of inferomarginal spines is proximally 4 (sometimes 5), the 2 innermost decreasing in size along the ray. The innermost spine is reduced to an inconspicuous spinule very soon, while the next persists for a variable distance, there being usually on the outer half only 2 prominent spines, the 2 outer ones of the proximal half. Between these two there is often 1 or 2 prominent pedicellariae, with 2 or 3 jaws similar in form to those of the adambulacral plates, but only about two-thirds as long, and a trifle stouter. In the Misaki specimen the inferomarginal pedicellariae are fewer and only about half or less than half the length of the larger adambulacral pedicellariae.

The specimen from the Tawi Tawi Islands is young (R equaling 36 mm.), but more typical in appearance. The paxillae are quadrate, close-set, and there are 3 adambulacral spines, followed by a large pedicellaria, which, however, belongs to the actinal intermediate plate. This pedicellaria is not present beyond the middle of ray. Inferomarginal spines, generally 2.

The Palawan specimens differ, therefore, from typical *L. maculata* in having smaller, roundish paxillae with fewer spinelets, and in having prominent *superomarginal pedicellariae*. Specimens from numerous Philippine localities must be examined before the status of these variations can be satisfactorily determined.

Type.—In the Museum of Leyden (Müller and Troschel).

Type-locality.—Japan.

Distribution.—Japan: Macclesfield Bank; Philippine Islands; Singapore; Malacca; Mergui Archipelago; Andaman Islands; India (Coromandel, Tuticorin, Madras, Bay of Balasore, Ceylon); Mozambique; Java Sea; Aru Islands; Torres Straits.

Specimens examined.—Three.

Station 5164, 8 miles northeast Observation Island, Tawi Tawi Group, Sulu Archipelago, 18 fathoms, green mud; 1 specimen.

Station 5346, Malampaya Sound, Palawan (10° 50′ 30″ N.; 119° 22′ 20″ E.), 7 fathoms mud; 1 specimen.

LUIDIA SAVIGNYI (Audouin).

Asterias savignyi Audouin, Description de l' Égypte, Echinodermes, 1809, p. 209, pl. 3.

Luidia savignyi Gray, 1840, p. 183.—Perrier, 1875, p. 340.

Luidia savignii (part) Müller and Troschel, 1842, p. 77. For description and bibliography see Perrier, 1875, p. 340; De Loriol, 1885, p. 72; Koehler, 1910*a*, p. 10, pl. 1, fig. 5, pl. 6, fig. 3.

A small seven-rayed specimen is referred to this species. There is little doubt that it represents true *L. savignyi*, although there are as yet no adambulacral pedicellariae. R=27 mm., r=5 mm. Adambulacral spines 3, or sometimes 4, there being a spine out of line (adorally) between the second and third spines. The abactinal spines are very stout. Koehler (1910*a*, p. 10) gives excellent critical and descriptive notes, and a photographic figure of the abactinal surface of a specimen from the Andaman Islands and of another from Mauritius.

The specimens recorded from Portuguese East Africa by Simpson and Brown (1910, p. 49) as *L. aspera* probably belong to this species. They have 7 rays. *L. savignyi* is not mentioned by the authors cited.

Type-locality.—Red Sea.

Distribution.—Red Sea; east coast of Africa; Mauritius; Andaman Islands; Sulu Archipelago; Philippine Islands.

Specimen examined.—Station 5159, Tinakta Island, Tawi Tawi Group, Sulu Archipelago, 10 fathoms, coral sand.

LUIDIA ASPERA Sladen.

Luidia aspera SLADEN, 1889, p. 248, pl. 43, figs. 1 and 2; pl. 45, figs. 9 and 10.

The single specimen is small (R=46 mm.) and has 8 rays. Koehler (1910*a*, p. 15) remarks that *L. aspera* is very close to *L. savignyi*, and that the differences between the two species concern the number of inferomarginal spines, and the number of rays (7 in *savignyi*, 8 to 10 in *aspera*). It seems to me that the two species are extremely close. I regret that there is not adequate material to throw more light upon their relationship.

In the Sulu specimen the spine-bearing paxillae (irregularly distributed in 3 series on either side) are separated by 2 rows of plain paxillae from the inferomarginal plates, except at the base of the ray, where 3 are present, as in Sladen's type. There are 3 well-developed adambulacral spines in a transverse series, the middle the longest, followed by 1 large pedicellaria having 3 (occasionally 2) slender, sometimes narrowly spatulate, jaws, over half (often three-fourths) as long as the longest spine. There are commonly 3 prominent inferomarginal spines, with or without a small spine at inner end of plate; or 2 prominent spines followed by 2 smaller spines. In the type there are 4 to 6 in a transverse series. The smaller number of marginal spines and the absence of a second adambulacral pedicellaria in my specimen may well be due to its immaturity.

The record of *L. aspera* from Portuguese East Africa (Simpson and Brown, 1910, p. 49) probably refers to *L. savignyi*, as mentioned under that species.

Type.—In British Museum.

Type-locality.—Not stated definitely; description based on specimens from off Zamboanga and Tablas Island, Philippine Islands, 10 to 115 fathoms, and from north of Admiralty Island, 150 fathoms.

Distribution.—Philippine Islands, Admiralty Island; 9 to 150 fathoms, green mud, coral mud, coral.

Specimen examined.—Station 5165, off Observation Island, Tawi Tawi Group, Sulu Archipelago, 9 fathoms, coral.

LUIDIA AVICULARIA Fisher.

Plate 43, fig. 1; plate 44, fig. 2 (see also plate 44, fig. 3, *L. moroisoana*); plate 46, figs. 2, 2*a*–*c*.

Luidia avicularia Fisher, 1913*c*, p. 203.

Diagnosis.—Very closely related to *L. integra* Koehler, which it resembles in general appearance but from which it differs in the following particulars: Scattered spinopaxillae among the normal paxillae of the 3 dorsolateral series; superomarginal and abactinal paxillae with small two-jawed pedicellariae; central spinelets of superomarginal and abactinal paxillae, sharp, longer than thick, not granuliform; inferomarginals encroaching conspicuously upon abactinal area and with marginal spines varying from 2 to 6; inferomarginal pedicellariae present on some of the plates; the characteristic furrow pedicellariae, proximally with dorsal jaw curved over end of the slightly curved ventral jaw; proximal adambulacral plates with generally more than 3 spines, and more than 1 subambulacral pedicellaria, pedicellariae sometimes replacing the spines; generally 2 large dental pedicellariae, directed over the peristome. Rays 10. R=195 mm., r=18 mm., R=10.5 r; a shorter ray, R=175 mm.; breadth of ray at base, 13 mm.; breadth 15 mm. from base, at widest part, 17 to 18 mm. Ray gradually tapering, blunt, abactinal surface slightly convex.

Description.—The most important abactinal feature in which *avicularia* differs from *integra* is in the presence of relatively few, central, sharp spines (smaller than those of the superomarginal plates) on the 3 dorsolateral regular rows of paxillae, the rather more rounded contour of the latter, and the presence on many of the paxillae (both superomarginal and abactinal) of a small two-jawed, spiniform pedicellaria. On the abactinal plates the pedicellaria is generally marginal and about as long as the peripheral spinelets. On the superomarginal paxillae (where 2 pedicellariae are occasionally present) it frequently is found at the outer adoral corner, or near the proximal rather than the distal transverse margin. The armature of the center of the tabulum consists of upward of 15 sharp, short spinelets (not granules) surrounding, without definite order, the stout, sharp central spinule, which varies in length from a little longer to a little shorter than the width of paxilla crown. The peripheral spinelets are slender and upward of 30. Another difference, rather striking, but possibly not constant, is the fact that when viewed from above the inferomarginals form a broad border to the abactinal area, often equaling the combined width of the 2 adjacent series of paxillae. I am inclined to think this is constant and due to the more arched inferomarginals. The upper end of the inferomarginals, judging by Koehler's photographic figures, are not at all conspicuous in *integra*.

The inferomarginal plates have a strong crest or ridge and encroach narrowly upon the actinal surface. Their armature is less constant than in *integra* and varies from 3 to 6 spines, but is usually either 3 or 4, less commonly 5, rarely 6. Sometimes there are 3 large, spaced spines, increasing in length toward the outer (which equals 2.5 or 3 plates in length); sometimes 2 shorter internal spines are followed by a pair of larger, more widely spaced spines: again, 1 or 2 small inner spines are followed by 2 (or 3) larger, the upper end of the plate being occupied by 1 or 2 abruptly smaller spines (4 to 6 in all). On the outer part of the ray there are usually 3 spines, and near the tip 2, only. A number of plates, especially adorally, have 1 or 2 two-jawed pedicellariae near the middle of the adoral margin of the crest, varying in size but smaller than the large subambulacral pedicellaria. These are lacking in *integra.*

A single series of actinal intermediate plates is present, which beyond the twelfth or thirteenth inferomarginal bear no spinelets or pedicellariae; the proximal ones bear a tuft of slender spinelets.

Beyond the basal fourth of the ray the adambulacral armature consists of 3 spines (often 4, rarely 5) in a transverse series, the median usually the longest, with a large two-jawed, slender, tapering pedicellaria just adorad of the outer spine and another very slender one under the saber-shaped furrow spine, much as described by Koehler for *integra.* The subambulacral pedicellaria is lacking on the outer two-fifths of the ray, its place being occupied by 1 to 3 small, slender spinelets. On the basal fourth of the ray the armature is not so uniform. First, in the furrow is the peculiar slender pedicellaria, oriented as described by Koehler, one valve dorsal, the other ventral. The dorsal valve (the lower, as viewed with specimen on its back) is the longer and is frequently curved over the end of the ventral, which is itself slightly curved, the pedicellaria resembling, perhaps a bit fancifully, the beak of a procellariform bird in miniature. Next comes the strongly compressed, curved furrow spine proper, followed by a still longer, compressed spine, or, not infrequently, by 1 or 2 long two-jawed pedicellariae in its place. Following this is sometimes the normal third spine, here the longest, with its adoral large pedicellaria, or 2 large pedicellariae, accompanied by 2 or 3 unequal slender spinelets or even 1 or 2 small two-jawed slender pedicellariae on the adoral edge of plate. Instead of the single third spine there may be 2 in a longitudinal series, or a triangular group of 3, with or without the large pedicellaria. Sometimes there are 5 spines in a transverse row, with 1 or more pedicellariae adorad to them. Apparently any of the spines, except the true furrow spine, may have a pedicellaria substituted for it, all of which affords a great variety to the armature of the proximal plates. The figures will give a better idea than description of the relative size of the pedicellariae and spines of typical plates. Even here there is variation in the size of the pedicellariae and relative lengths of the 3 or 4 spines.

The jaws are very narrow, and the pair form a sort of crest, along the top of which, bordering the median suture, are upward of 20 spines to each plate, increasing very rapidly in length toward the innermost, which is two-thirds as long as the interradial length of the plates. On the true, short margin, facing actinostome, are often 2 large two-jawed pedicellariae with a spine or two between them, that which is under the above-mentioned long superficial spine having jaws slender and half the interradial length of the plate, or slightly more. The lateral pedicellaria is smaller—one-third to two-thirds the length of the larger one. These pedicellariae are not present in *integra*.

Anatomical notes.—The gonads extend in a series of distinct tufts far along the ray, and each gonoduct opens on the inner proximal angle, between the processes of the base of the paxillae adjacent to the superomarginal. The paxillae of the 3 regular dorsolateral series have a cruciform base, either transverse process being a little longer than the 2 longitudinally directed ones, but the superomarginals are more nearly lozenge shape, longer than wide, with sometimes 2 processes on the side next to the adjacent paxillae. The median small paxillae have 3 or 4 short lobes, irregularly placed.

Type.—Cat. No. 32624, U.S.N.M.

Type-locality.—Station 5391, between Samar and Masbate (lat. 12° 13′ 15″ N.; long. 124° 05′ 03″ E.), 118 fathoms, bottom unrecorded; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—*Luidia integra* Koehler (1910*a*, p. 18; pl. 2, figs. 5–8) was taken by the *Investigator* off the Andaman Islands (lat. 13° 06′ N.; long. 93° 08′ E.), 60 to 75 fathoms. *L. avicularia* very closely resembles it, and is evidently what is sometimes called a representative species. As only one specimen of each species is known, some of the differences enumerated in the diagnosis may not prove to be constant.

I have been able to compare the type of *avicularia* with an excellent example of *L. moroisoana* Goto, from station 3739, Sagami Bay, Japan, 55 to 65 fathoms, volcanic sand, shells, rocks. This specimen is in the United States National Museum, and a portion of the abactinal surface, enlarged, is figured on plate 44, figure 3. The two species, although greatly resembling one another, appear to be entirely distinct. Their characters are contrasted below:

avicularia.	*moroisoana.*
Color, in alcohol, yellowish—a faded yellow-ochre.	Color, in alcohol, a sort of pinkish brown or sepia, with a violet shade.
Superomarginal spines inconspicuous, the series interrupted and the spines short, very unequal, usually less than half the length of the adjacent inferomarginal spine, and less than 1.5 the breadth of the paxillar crown in length.	A definite, conspicuous, uninterrupted row of sharp, acicular, superomarginal spines, each spine more than half the length of the adjacent (longest) inferomarginal spine, and length 1.5 to 2 times the breadth of the superomarginal paxillar crown.
A second longitudinal series of abactinal spines not present except near tip of ray, with a few scattered spines proximally, which are much less conspicuous than in *moroisoana*.	A second conspicuous longitudinal series of spines, much interrupted, between which and the superomarginal spines is a single series of unarmed paxillae.
Paxillae of rays more open, the central spinelets distinctly spiniform, and all spinelets longer.	Paxillae more compact, the central spinelets distinctly *granuliform*, and all spinelets shorter.
Largest paxilla from radial region at very base of ray with 10 to 15 slender spinelets, only slightly stouter than the peripheral, the latter equal in length to about one-half the width of tabulum.	Largest paxillae from radial region at very base of ray, with 8 to 10 mostly 8, central, acorn-shaped granules, much stouter than the 20 or more peripheral spinelets, which in length are less than one-third the width of the tabulum.
Furrow pedicellariae usually curved at the tip, the jaw nearer the bottom of furrow being the *longer*, and often curved over the end of the other, just the reverse of the condition of *moroisoana*.	Furrow pedicellariae usually with straight jaws, that nearest the bottom of furrow often slightly the shorter. (Goto, 1914, fig. 101.)

LUIDIA GYMNOCH

Plate 42, figs. 1, 2; plate 44, figs. 4, 5; plate 46, figs. 1, 1*a–d*.

Luidia gymnochora Fisher, 1913*c*, p. 204.

Diagnosis.—Related to *Luidia denudata* Koehler, but differing in having constantly 11 rays; prominent, central, two-jawed paxillar pedicellariae, together with several small two-jawed pedicellariae on the sides of the pedicels, superomarginal and dorsolateral spinopaxillae distally; with the transverse processes of the regular paxillae longer than the longitudinal (the reverse in *denudata*); frequently 3 or 4 inferomarginal spines; 1 to 5 inferomarginal pedicellariae; inferomarginals broader actinally, the intervening naked places much wider than long, and elliptical to oblong in form; 1 or 2 pedicellariae on the actinal intermediate plates; no slender furrow pedicellaria beyond a few plates at base of ray, except rarely and sporadically; second furrow spine compressed; several subambulacral pedicellariae, the principal one situated adorad of the second and third spine; rays 11. R=230 mm., r=33 mm.; breadth of ray at base 22 mm., a short distance beyond base 28 mm.; rays deciduous and usually imperfect, the tips being in the process of regeneration or absent; many rays are broken into 2 or 3 pieces; rays thin, plane, with very widely open, shallow ambulacral furrows; tube feet long, sometimes reaching to the margin, and with a small conical button at tip: skeleton loose, dorsal integument thin.

Description.—Paxillae of disk rather more closely placed (especially in the middle) than on rays. Each consists of a rather slender shaft (slenderest at the middle) surmounted by a circle of 8 to 12 very slender, sharp spinelets, about as long as the shaft, and surrounding a large central two-jawed tapering pedicellaria, which is a little longer than the spinelets. Seen from the side the pedicellaria is about 2 to 2.5 times as long as the width of the base. The joints are nearly of an equal width the whole length, or they taper slightly, or are very narrowly spatulate. Below the base of the spinelets fastened to the side of the shaft are 1 to 5 delicate, slender, blunt, two-jawed pedicellariae from one-half to two-thirds the length of the spinelets, and frequently oriented at right angles to the shaft. In the type nearly all the paxillae of the disk have the large central pedicellaria. They are not so numerous in a young specimen. The pedicellariae are entirely lacking in *L. denudata.*

On either side of the rays there are 3 regular series of large paxillae, the outer series of which represents the superomarginals. Over the median part of the ray the paxillae are smaller and arranged without definite order. Nearly all the paxillae have the pedicellariae described above, except in the case of regenerating tips, where they are much less common. On the outer half of the ray the central pedicellaria of the 3 regular series is replaced by a slender, sharp spine. This usually remains small on the median series, but increases in size on the other 2 series as the end of the ray is approached. It augments in size more rapidly on the inner series and attains a length of 5 to 10 times the height of the here much-shortened pedicels. These distal spinopaxillae are quite constant, although occasionally a paxilla will lack a spine, or the length of the spines will vary. Many of the other paxillae of the distal fourth of the ray have the pedicellaria replaced by a spine, but the latter does not surpass the other spinelets enough to become conspicuous. These spinopaxillae are not present in *denudata.*

The regular paxillae have regularly four-lobed or cruciform bases, the transverse lobes being longer than the longitudinal ones (the reverse in *denudata*). The papular areas are nearly square and not oblong as in *denudata*. The superomarginals are without external transverse lobes, being fastened directly to the inferomarginals. Between the 2 triple ranges of regular larger paxillae, the plates have 3 or 4 usually unequal lobes which overlap a trifle, just touch, or fail to touch by a narrow interval. This causes the dorsal skeleton to be very flexible. The papulae extend to very nearly the tip of ray, and are compound, consisting, when fully developed, of upward of 30 slender coeca, branching from a common base, and reminding one of a coral fungus in miniature. One compound papula occupies an area, the latter being irregular in shape on the median region of ray.

The inferomarginals have the form of those of *denudata*, but the ventral apophysis, which meets the intermediate plate, and by means of it is joined to the corresponding adambulacral, is decidedly longer, so that the prominent naked spaces (covered by thin integument) which separate consecutive inferomarginal plates are much wider than long, and in shape are elliptical, elongate-oval, or oblong with rounded corners. In *denudata* the shape is that of an equilateral triangle with rounded angles. Ventrally each inferomarginal forms a low crest, but is produced laterally into a thin ridge, with a rounded outer free surface. This ridge, which separates wide fasciolar channels, corresponds to the shaft of one of the abactinal paxillae, while the homologues of the four basal lobes are readily traced, the ventral apophysis spoken of above being one. Consecutive plates are joined by 2 longitudinally directed lobes, while the fourth is very short or wanting where the plate is closely joined to its corresponding superomarginal. The exact form of the plates and the dimensions may best be gathered from the figures. The summit of the lateral crest bears 2 large spines, the outer the longer, and equaling about 3 plates in length. One or 2 shorter and slenderer spines stand in line with the above on the ventral surface, and dorsal to the large spine are 8 to 12 slender, unequal spinules. Numerous spaced similar spinules surround the main spines and are continued along the ventral surface. Each plate bears from 1 to 5 unequal, rather slender two-jawed pedicellariae, the largest of which frequently stands on the inner extension of the plate, while other small ones are found on either transverse margin of the crest, near the second (lower) lateral spine, or between that and the third. The pedicellariae are lacking in *denudata*, which has only 2 inferomarginal spines.

The actinal intermediate plates are much wider than long, and each is truncate where joined to the inferomarginal, but the inner end which overlaps the adambulacral is rounded and narrower than the outer. Except on the outer third or fourth of ray, nearly all the plates bear 1 or 2 (rarely 3) two-jawed pedicellariae, similar to the subambulacral and inferomarginal pedicellariae. The second pedicellaria is usually considerably smaller than the other, which is about as long as the transverse diameter of the plate. The plates are armed also with 2 to 5, but sometimes upward of 10, very slender, fairly long, spinelets about as large as those of inferomarginal plates. The pedicellariae are lacking in *denudata*.

Except on the first 8 to 12 plates at base of ray, the characteristic furrow pedicellaria of *denudata* occurs very rarely in the type, but in specimens from stations 5402 and 5406 it occurs more frequently, at least on some rays. At best its occurrence is sporadic. The pedicellaria is very slender and resembles a compressed truncate furrow spine, the thin jaws being oriented distal and proximal, or at right angles to the pedicellaria of *avicularia*. It is about two-thirds the length of the furrow spine.

The adambulacral armature consists of a transverse series of 3 rather long spines, increasing in length outward, the inner 2 being compressed. The outer is occasionally a little out of line, being crowded by a large two-jawed slender pedicellaria on its proximal side, or opposite the interval between the second and third spines. One or two small pedicellariae are usually found just adorad of the above, while another is sometimes present just external to the outermost spine, along with 2 or 3 delicate spinelets. This outer pedicellaria varies greatly in size. At the base of the ray the spines are very compressed and form a vertical series between the tube feet, the outer spine only being bent away. Here there are usually 2 or 3 large subambulacral pedicellariae, with several small ones at their base. Also the proximal plates frequently have the furrow pedicellaria. It resembles a supernumerary compressed bladelike furrow spine below the regular spine. As in *L. avicularia*, the armature at the base of ray is variable and not typical of most of the adambulacral plates. On the outer third or fourth of ray, or even over a greater extent of the distal region, the subambulacral pedicellariae are lacking, there being 3 spines in a transverse series, with a few (2 or 3) slender spinelets standing just adorad of the outer spine. The armature differs from that of *denudata* in lacking usually the furrow pedicellaria, in having the second spine strongly compressed, not terete, and in having a characteristic pedicellaria adorad of the third spine, or the second and third, in addition to 1 or more smaller accessory pedicellariae. In *denudata* the only subambulacral pedicellaria is situated external to the external spine, where, in *gymnochora*, a small or medium-sized pedicellaria is often present.

The armature of the mouth plates consists of (1) a superficial series bordering the median suture, consisting of 8 to 12 spines and spinules, the 2 innermost long and stout, followed by a number of small spinelets and two-jawed pedicellariae, the outer end being occupied by slender spinules of intermediate length. Sometimes there are 3 inner enlarged spines or the second may be replaced by a long, slender, 2-jawed pedicellaria. (2) At the inner end of plate extending over the peristome, and near to it is a horizontal fan consisting of a long "tooth," a long two-jawed pedicellaria, and at the mouth of furrow another smaller spine, at the base of which is sometimes a small pedicellaria. Sometimes this series consists of the tooth and 2 or 3 pedicellariae, several variations occurring. (3) Near the inner end of the plate on its sloping face is an intermediate series of 3 (sometimes 4) prominent compressed spines, or a pedicellaria and 2 spines. These spines extend over the mouth of the furrow and form a series with the innermost superficial spine (which is directly back of the enlarged tooth).

Color in alcohol: Bleached yellowish, the epidermis of the abactinal surface, beneath the paxillae, bleached brown or a decided burnt sienna.

The gonads extend in a series of tufts to the end of the ray. The series underlies the row of paxillae adjacent to the superomarginals.

Variations.—The most important variations have been mentioned in the foregoing description. I notice that in the specimen from station 5404 the outer or principal subambulacral spine is occasionally replaced by a pedicellaria, beyond which is another, corresponding to the subambulacral pedicellaria of *denudata*, making a series of 2 spines and 2 pedicellariae. The width of the naked spaces between the inner ends of the inferomarginals is subject to slight variation. They are, however, always broader than long. Specimens from the deepest water (stations 5189 and 5406) have slightly slenderer pedicellariae than the type.

Young.—A specimen with R 86 mm. (station 5406) is characterized by having less numerous pedicellariae than the adult or large specimens. The actinal intermediate plates have a pedicellaria at the base of the ray only, furrow pedicellaria is absent, and beyond the middle of the ray there are no subambulacral pedicellariae; the proximal plates have a single pedicellaria adoral to the outer spine. The inferomarginal pedicellariae are restricted to 1 or 2 on the proximal plates only.

Type.—Cat. No. 32625, U.S.N.M.

Type-locality.—Station 5409, between Cebu and Leyte, 20.8 miles southeast of Capitancillo Light, Cebu, 189 fathoms, green mud; 1 specimen.

Distribution.—Philippine Islands (vicinity of Negros, Cebu, and Leyte), 188 to 300 fathoms, mud. Temperature range, 55.4° to 62.8° F.

Specimens examined.—Six, the type and 5 from the following Philippine localities:

Station 5189, Tanon Strait, east coast of Negros, 300 fathoms green mud, bottom temperature 62.8°; 1 specimen.

Station 5402, near type-locality, 188 fathoms, green mud, bottom temperature 55.8°; 1 specimen.

Station 5404, 6.8 miles northwest Ponson Island, Dupon Bay, Leyte, 190 fathoms, mud, bottom temperature 55.4°; 1 specimen.

Station 5406, same locality (10.2 miles northwest Ponson Island), 298 fathoms, mud; 2 specimens.

Remarks.—*L. gymnochora*—the name referring to the bare spaces between the inferomarginals—shows a great resemblance to *L. denudata* Koehler from the Coromandel coast, India, 133 fathoms. This resemblance concerns not only the superficial appearance, but the structure of the skeleton, including the form of the paxillae. As enumerated in the diagnosis there are a number of important differences, chief among which are the broader inferomarginals of *gymnochora*, the broader dorsolateral paxillar bases, broader actinal bare spaces, and the presence of numerous abactinal, inferomarginal, actinal intermediate, and subambulacral pedicellariae.

The looseness and flexibility of the skeleton, along with the relatively large size of the tube feet suggests that this form can swim. It would be interesting to know if the tip of so many rays has been lost in an effort to escape from enemies or from actual attacks of other animals.

Family ARCHASTERIDAE.

Genus ARCHASTER Müller and Troschel.

Archaster Müller and Troschel, 1840*a*, p. 104.

ARCHASTER TYPICUS Müller and Troschel.

Archaster typicus Müller and Troschel, 1840*a*, p. 104.

About 900 specimens were taken at the following localities:

Point Jamelo, Luzon, with seine, 3.

Nasugbu, Luzon, reef, 5.

Subig Bay, Luzon, shore, 31.

Santiago River, Pagapas Bay, Luzon, 3.

Tilig, Lubang, 5 medium-sized specimens and about 800 young with R, 5 to 15 mm.

Olongapo, Luzon, 2.

Sablayan, Mindoro, tide pool, 1.

Romblon Island, east of Tablas Island, shore, 16.

Pandanon Island, between Cebu and Bohol, 2.

San Pascual, Burias, tide pool, 3.

Busin Harbor, Burias, shore, 8.

Cuyo Island, west of Panay, 2.
Verde del Sur Island, Palawan, 2.
Makesi Island, Palawan, 3.
Caxisigan Island, Balabac (southwest end of Palawan), 7.
Linapacan Island (north end of Palawan), 5.
Murcielagos Bay, Mindanao, 10.
Opal, Mindanao, 1.
Parang, Mindanao, shore, 1.
Capunuypugan, Mindanao, 2.
Zamboanga, Mindanao, Dr. E. A. Mearns, 2.
Mantacas Island, west coast Bohol, shore, 4.
Cagayan Sulu Island, Sulu Sea, 2.
Sandakan Harbor, Borneo, 3.
Papatag Island, Tawi Tawi Group, shore, 4.
Simulac Island, Tawi Tawi Group, 8.

This species is widely distributed over the Pacific and Indian regions. Although Sladen records *Archaster angulatus* and not *A. typicus* from the Philippines, the latter appears to be the commoner form. No specimen of *angulatus* was taken by the *Albatross* at the shore stations, and only one was dredged, as recorded below. These specimens seem to be typical. Some specimens have a variable number of superomarginal spines and some lack them entirely.

ARCHASTER ANGULATUS Müller and Troschel.

Plate 45, fig. 3.

Archaster angulatus Müller and Troschel, 1842, p. 66.—P. de Loriol, 1885, p. 78, pl. 22, fig. 2.

This species may be readily distinguished from *A. typicus* by the presence of 2 or 3 enlarged squamiform spinelets at the outer end of the inferomarginal plates in place of the single prominent lateral flattened spine of *typicus*. The specimen collected by the *Albatross* is small, and the rays are decidedly slenderer than in *typicus*. The superomarginals encroach conspicuously upon the abactinal area—a condition which is not true of large specimens of typical *angulatus*. There are no signs of any superomarginal spines. At the outer aboral corner of the inferomarginal plates 2 to 4 spinelets are enlarged and become squamiform, but none is prominent. The median radial row of paxillae is very regular. The first adambulacral plate has 6 furrow spinelets, the next 3 have 4, and the rest have 3. The proximal plates usually have 2 longitudinal series of subambulacral spinelets: In the first row, 3, or 2 and a two-jawed equally long pedicellaria between them; in the outer row, usually 2 spinelets, 1 at each outer corner of the plate. A difference in the number of paxillar spinelets is also noticeable, a fairly large lateral paxilla having 1 to 4 central and 8 to 10 peripheral spinelets, while a proximal radial plate bears 8 or 9 central and about 15 peripheral spinelets (in addition occasionally to an equally long tapering spiniform pedicellaria). In fully grown examples of *typicus* from Samoa corresponding lateral paxillae have 6 or 7 spinelets only (usually all peripheral) and the median radial 7 or 8 (occasionally 1 central). The measurements of the specimen are: R = 32 mm., r = 6 mm., R = 5.3 r; breadth of ray at base, 7 mm.

Type-locality.—"Java; Isle de France."

Distribution.—Mauritius, Java, Philippine Islands, Port Darwin; Torres Strait; Freemantle, W. Australia; New Guinea; Fiji Islands (Studer).

Specimen examined.—Station 5165, off Observation Island, southwest end of Tawi Tawi Island, Sulu Archipelago, 9 fathoms, coral; 1 specimen.

Family BENTHOPECTINIDAE Verrill.

Genus PECTINASTER Perrier.

Pectinaster PERRIER, Ann. sci. nat., vol. 19, 1885, p. 70. Type, *P. filholi* Perrier.

KEY TO THE SPECIES AND SUBSPECIES OF PECTINASTER HEREIN DESCRIBED.

*a*¹. Central spine of paxillae absent from a narrow area at either side of paxillar area of ray; 15 to 18 adambulacral plates correspond to first 10 inferomarginals; marginal spinelets fewer, a bare space on the central part of marginal plates.
  *b*¹. Spinelets accompanying abactinal spines not greatly reduced in number on middle and distal portions of ray; marginal spines moderately robust .... *mimicus*, p. 182.
  *b*². Abactinal plates of ray with very few spinelets accompanying the spine (1 to 4, distally, 0); marginal spines robust. *palawanensis*, p. 185.
*a*². Central spine of paxillae distributed abundantly all over abactinal area; 13, rarely 14, adambulacral plates to first 10 inferomarginals; marginal spines more numerous, no well-defined bare space on the plates. *hylacanthus*, p. 187.

PECTINASTER MIMICUS (Sladen).

Plate 49, fig. 1.

Pontaster mimicus SLADEN, 1889, p. 48, pl. 4, figs. 1 and 2; pl. 7, figs. 5 and 6.

Pectinaster mimicus, PERRIER, 1894, p. 279.—LUDWIG, 1910, p. 449.—FISHER, 1911*d*, p. 126.

Notes on specimens.—I have experienced great difficulty in applying a name to these specimens, there being three in the field which might prove to be applicable: *P. mimicus*, *P. hispidus* (Wood-Mason and Alcock), and *P. forcipatus*, var. *echinatus* (Sladen). Wood-Mason and Alcock do not state definitely wherein their species differs from *P. mimicus*. According to Ludwig, 1910 (p. 450), *mimicus* has the abactinal spines on the disk and along the median portion of the ray (as stated by Sladen), while in *hispidus* the spines are all over the abactinal surface. The first has pedicellariae on the interradial areas only, while in the second they may occur on the marginal and abactinal plates. Both have 5 to 7 furrow spines and 15 adambulacrals corresponding to the first 10 inferomarginals. Wood-Mason and Alcock state, however, that the abactinal spines occur numerously on the disk and *along the central axis of ray.* They record intermarginal pedicellariae. These occur, in variable numbers, in the *Albatross* specimens from stations 5606, 5608, 5609, 5668, but not in those from stations 5630, 5660, and in 2 examples from 5608.

In the *Albatross* specimens the abactinal spines are absent or else very few and widely scattered on the lateral portions of the paxillar area of ray, but apparently a little more widely distributed than in Sladen's type, and apparently a little less than in Ludwig's conception of *hispidus.* However, in some specimens their distribution just about coincides with that in Alcock's figure of *hispidus* (1894, Echinoderms, pl. 2, fig. 5*a*). This character is slightly variable.

I have not used the name *hispidus* for these specimens, although the abundance of pedicellariae in some of the examples would seem to indicate their close alliance if not identity with that form, because the occurrence of pedicellariae is subject to great variation and also because Wood-Mason and Alcock state that the marginal plates are *closely covered* with capillary spinelets. In the *Albatross* specimens the spinelets are more spaced, as described for *mimicus.* Likewise the *Albatross* specimens are from nearer the type-locality of *mimicus.* I fully agree with Koehler that the differences, so far as known, between *hispidus* and *mimicus* are rather subtle.

The following table indicates some of the variations in the specimens examined:

Station.	No. of adambulacral plates to first 10 inferomarginals.	No. of furrow spines proximally.	Actinal interradial pedicellariae.	Actinal inferomarginal pedicellariae.	Intermarginal pedicellariae.	Abactinal pedicellariae.	r in mm.	Depth, fathoms.
5606	17 (16)	7–9	Abundant.	To far along ray	Several, interbrachial.	None....	11	834
5608*a*	15	6–7	...do.......	Proximal half of ray.	1 or 2 interbrachial.	...do	7.5	1,089
5608*b*	15 (14)	6–7	3–6........	None..........	None..........	...do	6	1,089
5608*c*	15 (13, 14)	6	Numerous.	Few...........	...do	...do	6.5	1,089
5609	17 (16½)	5–6	...do	Proximal half of ray.	1 to 3 interbrachial.	Few.....	9.5	1,092
5630*a*	15½–18	5–6	7–9........	None..........	None..........	None....	12	569
[1] 5630*b*	15	5–6	None......	...do	...do	...do	6	569
5660	15	6–7	5–6........	Few...........	...do	...do	11.5	692
5668*a*	15 (16)	8–9	Numerous.	Far along ray..	Interbrachial and along ray.	Few.....	9	901
5668*b*	17	7–8	...do.......	.....do.........	.....do.........	Very few	8.5	901

---

[1] Young.

The large specimen from station 5630, it will be noted, has pedicellariae only on the actinal interradial areas. It is of a stouter build than the other specimens, the marginal spines being very robust. This, and to a less extent the specimen from station 5660 (also from a lesser depth than the majority of examples), resemble the form called "*Pontaster forcipatus*, var. *echinata*," by Sladen. The stouter habit may be correlated with the difference in depth. Koehler also notes a similarity to *echinatus* in some of his specimens of *hispidus* (1909, p. 12). It would be interesting to know if these specimens are likewise from shallower water (stations 250 and 317, 480 and 590 fathoms).

The number of adambulacrals to the first 10 inferomarginals varies in full-sized specimens from 15 to 18, but 15, 16½, or 17 is the usual number.

The abactinal paxillae conform to the figures and descriptions of Sladen, except that in specimens from stations 5609 and 5668 a few abactinal pedicellariae are present. These are found on the disk or base of rays and have 2 to 4 short jaws, thicker than the paxillar spinelets. Beyond the interbrachial arc the marginal plates have a considerable area around the spines in which the spinelets are irregularly and widely scattered. There are sometimes 2 accessory inferomarginal spines at the base of the ray. The inferomarginal pedicellariae, usually 1 but occasionally 2 to a plate, are subcircular and occur on the suture between the inferomarginal and adambulacral plates (with most of the spinelets on the former) or on the inferomarginal close to the lower edge. There are usually 4 to 6 stout, tapering, pointed jaws, much stouter than the neighboring spinelets. The actinal interradial pedicellariae stand on 1 or 2 plates, and when well developed have 7 or 8 jaws. They are usually subcircular, but sometimes assume a double-pectinate form, more as in *Cheiraster*, but retain the stout jaws. In *Cheiraster* the jaws of the pedicellariae are relatively slenderer.

On the outer part of the ray (sometimes for as much as the distal half) the adambulacral plates have a second smaller upright spine, situated between the principal subambulacral spine and the furrow margin. It occasionally nearly equals the principal spine in size, and seems to be, morphologically, an aboral furrow spine which has moved onto the surface of the plate. This spine is not mentioned by Sladen, but it might be easily overlooked.

The dorsal muscle bands are each attached to the outer end of fifth ambulacral plate (specimens from stations 5609, 5668) by a slender rather inconspicuous tendon, once to twice as long as the transverse dimension of the ambulacral plate. A second very inconspicuous tendon can be traced to the seventh plate, or to one of a few succeeding plates. The fifth ambulacral is higher than the others. This tendon seems to be smaller than in either *P. forcipatus* or *P. evoplus.*

In *P. hylacanthus* the attachment of the muscle is to the sixth or seventh ambulacral plate, and the tendon is even less conspicuous than in *mimicus.*

Type.—In the British Museum.

Type-locality.—*Challenger* station 191, Arafura Sea, northwest of the Aru Islands (lat. 5° 41′ S.; long. 134° 04′ 30″ E.), 800 fathoms, green mud, bottom temperature 39.5° Fahr.

Distribution.—Arafura Sea, Flores Sea, Strait of Macassar, and Celebes; recorded by Alcock and Wood-Mason from Laccadive Sea, 1,000 fathoms.[1] Including the race *palawanensis*, to Palawan Passage. Bathymetrical distribution 692 to 1092 fathoms. Range in temperature 36.3° to 39.5° F.

Specimens examined.—Thirteen, from the following stations:

Station 5606, Gulf of Tomini, Celebes (lat. 0° 16′ 28″ S.; long. 121° 33′ 30″ E.), 834 fathoms, green mud, 3 specimens.

Station 5608, Gulf of Tomini, Celebes (lat. 0° 08′ S.; long. 121° 19′ E.), 1,089 fathoms, gray mud, bottom temperature 36.3° F.; 3 specimens.

Station 5609, same locality, 1,092 fathoms, green mud, bottom temperature 36.3° F.; 1 specimen.

Station 5630, near Batjan Island, Molucca Islands, 835 fathoms; 2 specimens.

Station 5654, Gulf of Boni, Celebes, 805 fathoms, bottom not recorded, bottom temperature 38.3° F.; 1 specimen.

Station 5660, Flores Sea (lat. 5° 36′ 30″ S.; long. 120° 49′ E.), 692 fathoms, gray mud, sand, bottom temperature 39.2° F.; 1 specimen.

Station 5668, Macassar Strait (lat. 2° 28′ 15″ S.; long. 118° 49′ E.), 901 fathoms, gray mud, bottom temperature 38.2° F.; 2 specimens.

PECTINASTER MIMICUS PALAWANENSIS, new subspecies.

Plate 52, fig. 3; plate 54, figs. 2, 2*a*.

Diagnosis.—In general appearance, posture of superomarginal spine, and restriction of abactinal spines to central axis of ray, resembling *P. mimicus*, but differing in having, on the ray, much fewer granuliform spinelets accompanying the abactinal spines (beyond fifth superomarginal reduced to 1 to 5, or sometimes, distally, to 0); in connection with this difference the marginal and actinal spines are uniformly robust and there are very abundant actinal intermediate, inferomarginal, intermarginal, and a few abactinal pedicellariae; the spinelets of marginal plates are few, being reduced sometimes to a single series, rather widely spaced on edge of plate; and the general surface of the marginals, beyond the basal fourth of ray, is bare, or has only a very few widely scattered spinelets. R=about 95 mm., r=11.5 mm.; R=about 8 r; rays narrow, long with a very attenuate distal portion; 15.5 or 16 adambulacrals to first 10 inferomarginals.

---

[1] Possibly referable to a distinct race.

Description.—Beyond the fifth superomarginal, the central spine of the abactinal plates (which is generally absent from the lateral portions of area) is accompanied by 3 to 5—very rarely more—small spinelets, or by only 1 or 2. Sometimes the spinelets are entirely lacking, especially on the distal half of the ray. In some specimens the reduction is more accentuated. The other plates bear 1 to 5 (sometimes 0) inconspicuous spinelets. The average large paxillae of disk and basal portion of ray bear 5 to 15 granuliform spinelets in a single circle around the central spine. A variable, but usually small, number of fasciculate and pectinate pedicellariae, with 2 to 8 robust jaws, are scattered over disk and proximal half of ray.

Marginal spines stout. With the exception of the first 2 to 4 plates, the spinelets are relatively few and found mostly around the borders, sometimes fairly widely spaced and in a single series, with a few spinelets widely scattered over the general surface. The marginal series may even not be complete, or along the transverse borders 2 or even 3 series, usually irregular, may be present, with only 1 on the longitudinal margin. As a consequence most of the surface of the marginal plates is bare, and more of the surface of the superomarginals is unencumbered than of the inferomarginals. The second inferomarginal spine is stout, and on the first 2 or 3 plates a third is often present (as in *mimicus*). Certain superomarginals may have 2 spines, and inferomarginals 2 primary spines and 2 secondary, or 1 primary and 3 unequal secondary. These plates are irregular or inconstant in occurrence.

Adambulacrals with a salient furrow margin and 7 to 9 furrow spines, very similar to the armature of the typical form. The subambulacral spine is rather stouter than usual in *mimicus*, and distally there is a second smaller one (as in *mimicus*) between the furrow margin and the principal spine. The first 2 plates in 2 out of the 6 specimens have 2 subambulacrals. Mouth plates with 2 or 3 stout suborals and about 6 marginal spines, in addition to a series of 6 along the margin of median suture.

Pedicellariae abundant, and present: (1) Sparsely on the abactinal surface (pectinate and fasciculate); (2) in variable numbers on the suture separating the supero- and inferomarginal plates, both interbrachially and along the ray, or interbrachially only (fasciculate); sometimes these occur near the upper edge of an inferomarginal; (3) 1 to 3 pedicellariae near the inner edge of the inferomarginals or on the suture between inferomarginals and adambulacrals (fasciculate), these extending usually half to two-thirds the length of ray; the jaws are 3 to 6, stout, flattened, pointed, blunt, or truncate; (4) 10 to 22 fasciculate or fasciculate-pectinate pedicellariae on each interradial area. In addition to the pedicellariae, which have 2 to 8 jaws, the actinal intermediate plates bear a relatively few subequal papilliform spinelets.

The abactinal muscle bands are attached to the outer end of the fifth ambulacral ossicle which is conspicuously higher than the preceding ones; sometimes it is the fourth on one side of ray and fifth on the other.

Papular areas broadly elliptical, swollen, bisected by a line passing across ray at outer end of interradii; papular pores about 20.

Type.—Cat. No. 37003, U.S.N.M.

Type-locality.—Station 5349, Palawan Passage (lat. 10° 54′ N.; long. 118° 26′ 20″ E.), 730 fathoms, coral sand, bottom temperature 40.6° F.; 6 specimens, all more or less mutilated.

Distribution.—Known only from type-locality.

Remarks.—While this form is evidently very closely related to *P. mimicus*, it is not at all evident whether it represents a geographical race, or simply a local variation, because the specimens were all taken at a single haul. The characters seem to call for more formal recognition than would be accorded them under a discussion of variations.

This race, we may not unreasonably conjecture, occupies the China Sea basin at depths between 700 and 1,000 fathoms.

PECTINASTER HYLACANTHUS Fisher.

Plate 48, fig. 2; plate 49, fig. 2; plate 54, fig. 1.

Pectinaster hylacanthus FISHER, 1913*c*, p. 204.

Diagnosis.—Related to *P. mimicus* Sladen, from which it differs in having the central spines of the paxillae distributed all over the abactinal surface, and in having 13 (exceptionally 12 or 14) adambulacrals corresponding to the first 10 inferomarginals. R=79 mm., r=10.5 mm., R=7.5 r approximately; breadth of ray at base, 11 to 12 mm. General appearance similar to that of *P. mimicus;* disk small, rays long, slender, recurved at tip; superomarginal plates confined to side wall of ray, with an upright sharp spine close to, or on upper margin; normally no abactinal pedicellariae; abactinal spines numerous and generally distributed; small spinelets in 1 or sometimes 2 circles surrounding base of spine; adambulacral furrow spines 7 or 8 at base of ray; pedicellariae variable, present usually on actinal interradial areas, and sometimes also intermarginally, and on actinal surface of intermarginals.

Description.—Most of the abactinal paxillae with a central spinule, 0.75 to 1 mm. long; these spinules are uniformly distributed all over the abactinal surface, even to tip of ray, which has in consequence a hirsute appearance. The larger paxillae have 8 to 15 short blunt papilliform spinelets in a circle around the central slender terete spine. These stand upright or diverge slightly; they are not closely appressed to the base of the spine, as in Sladen's figure of *mimicus*. (But *mimicus* is variable in this respect.) These spinelets are present on the outer part of ray, but are smaller, and reduced to 3 to 6. Papularium very broadly oval, small, with 20 to 25 pores. A line drawn across the base of ray passes through the middle or outer half of the papularium. Abactinal pedicellariae normally absent; I find a single inconspicuous one in the type. There are none on a specimen from station 5619, plentifully supplied with actinal pedicellariae.

Superomarginals 41 (in type), confined to side wall of ray and bearing near the upper edge a stout conical spine, equaling (beyond the fourth or fifth) about 1½ to 1⅔ plates in length. It is a little shorter than that shown in Sladen's figure of *mimicus*, and a little shorter than in the *Albatross* specimens of *mimicus*. The general surface of the plate is covered with papilliform spinelets similar to those of the paxillae, but a little longer. These are slightly spaced, and are present all over the proximal plates, but distally they are widely spaced and leave an area around the base of the spine, nearly or quite bare. Rarely, near the middle of ray there are a few fasciculate pedicellariae on the intermarginal suture. These are present only in the type, which is from rather deeper water than the other specimens. There is also, in the type, in 3 interradii, a small intermarginal pedicellaria, similar to that which is rather characteristic of the form here called *mimicus*.

Inferomarginals with a stout, sharp, conical spine (3.5 mm. long), slightly larger than that of superomarginals, and close to upper edge of plate; below this, a smaller spine, about one-third or one-half as long. The tapering, bluntly-pointed spinelets are a little longer than described by Sladen for *mimicus* (but subequal to the spinelets in *Albatross* specimens of *mimicus*), and while they are rather widely spaced on the actinal surface, there is no definite naked area such as seems to be characteristic of *mimicus*. They can not by any stretch of the imagination be called granuliform.

Actinal interradial areas small and plates not extending beyond third inferomarginal. The plates bear spaced, short, slender, equal spinelets or upward of 8 or 10 pectinate-fasciculate and fasciculate pedicellariae to each interradial area. The type has 6 or 8 to each area, while in specimens from station 5619 they are present also on the ventral surface of upward of 10 or 15 proximal inferomarginals. The pedicellariae are subcircular, with 4 to 6 short, stout, pointed to truncate jaws (2 or 3 times thicker than the actinal spinelets) confined to a single plate, or sometimes shared by 2 plates (in interradial area). The pedicellariae are similar in form to those of *P. filholi* Perrier (=*forcipatus* Sladen).

Thirteen adambulacral plates (exceptionally 12 or 14) correspond to first 10 inferomarginals. Furrow margin of plate semicircular, about as salient as in *mimicus;* consecutive plates separated by an interval equal to about two-thirds or three-fourths the length of the plate, at base of ray. Furrow spines in type, 8 at base of ray, then 7, and on outer part of ray 9 or 10. It is difficult to determine exactly the number of furrow spines, because on the transverse margins of the plate are 1 to 3 spinules which partly or wholly form a part of the palmate furrow series (especially distally where the plates are narrow). There is 1 prominent tapering, sharp, sometimes slightly curved subambulacral spine about as long or a little longer than the adjacent inferomarginal plate. Frequently, but not always, near the above and the outer adoral corner of plate is a small spinule distinct from the spinules of the transverse margin, or rarely 2 or even 3 spinules may be present on a few proximal plates.

Marginal mouth spines, 6 or 7; about 7 spines along the median suture, flattened, pointed, and decreasing in length toward outer end of plate. On the surface of plate, near inner end, an intermediate series of about 3 spines (in small specimens 1 or 2 only), of which 1 is enlarged but is smaller than the homologous subambulacral spine.

Madreporic body situated about its own diameter (or a little more or less) from inner edge of marginal plates; striae coarse.

Anatomical notes.—The dorsal muscles are very stout and are found on the outer part of the ray. The end of the ray is usually recurved, and sometimes forms a spiral. The muscles of either side are attached to the dorsal body wall and to the outer end of the sixth or seventh ambulacral ossicle, which differs from the rest in being higher and having a special knoblike crest at the outer end for the attachment of the tendon. This tendon, in spite of the size of the muscle, is rather inconspicuous. The muscles are much heavier and the tendon longer and decidedly less conspicuous than in *P. agassizi evoplus* (from California) and *P. filholi* (from the Atlantic). These two species are also relatives of *P. mimicus.* The difference in the muscles alone will distinguish *hylacanthus* from *filholi* and *evoplus.* Not infrequently the muscles are so strongly contracted that they have entirely broken away from the tendon, which will be found, however, attached to the ambulacral ossicle (usually easily recognizable by its greater height).

Variations.—The most important variation in this species is in the occurrence of pedicellariae, which in the southern specimens are more numerous than in the northern. They may be almost or entirely absent (specimens from station 5445) or present on the actinal intermediate plates, and intermarginally (the type), or present interradially and on the actinal surface of the inferomarginals (station 5619). The small spinelets of the abactinal plates may sometimes form 2 concentric series around the central spine, the inner series, however, usually incomplete (station 5629).

Young specimens have few papular pores and few pedicellariae (when these are present in the adults from the same station). The relation of 10 inferomarginals to 13 adambulacrals is, however, maintained. The abactinal spines are present all over the abactinal surface in the smallest example examined (R=15 mm.).

Type.—Cat. No. 32626, U.S.N.M.

Type-locality.—Station 5467, Lagonoy Gulf, southeastern Luzon, 480 fathoms, green mud; 1 specimen.

Distribution.—Molucca Passage to north coast of Samar, 383 to 435 fathoms, green mud, fine gray sand; bottom temperature, 44.3° F.

Specimens examined.—Thirty-four.

Station 5444, north coast of Samar (lat. 12° 43′ 51″ N.; long. 124° 58′ 50″ E.), 308 fathoms, green mud, bottom temperature 45.3° F.; 1 specimen.

Station 5445, north coast of Samar (lat. 12° 44′ 42″ N.; long. 124° 59′ 50″ E.), 383 fathoms, green mud, sand, bottom temperature 44.3° F.; 19 specimens.

Station 5619, Molucca Passage (lat. 0° 35′ N.; long. 127° 14′ 40″ E.), 435 fathoms, fine gray sand; 13 specimens.

Remarks.—As indicated in the diagnosis this species closely resembles *P. mimicus*, from which it differs in having only 13 adambulacrals to the first 10 inferomarginals, while *mimicus* has 15 to 18. In *mimicus* the abactinal spines are absent from the lateral portions of the area, while in *hylacanthus* they are distributed all over the area.

P. mimicus inhabits depths of from 692 to 1,092 fathoms, subjected to a temperature of 36.3° to 39.5°, while *hylacanthus* is found in less than 500 fathoms, the only temperature record being 44.3°.

P. hylacanthus resembles very closely *Ch. niasicus*, the two occurring together at stations 5445 and 5619. The differences are pointed out under the latter species.

Genus CHEIRASTER Studer.

Cheiraster Studer, 1883, p. 129; 1884, p. 49. Type, *C. gazellae* Studer.

KEY TO THE SPECIES OF CHEIRASTER HEREIN DESCRIBED.

a^1. Some of the abactinal plates of either rays or disk, or both, with enlarged central spine at least 3 times as long as the peripheral spinelets.

$b.^1$ Central spine of abactinal plates present on disk and rays, sometimes very sparsely on the former.

$c.^1$ Numerous abactinal spines on disk as well as on the rays; pectinate pedicellariae on actinal intermediate plates and usually fasciculate pedicellariae on the inferomarginals_________*niasicus* Ludwig, p. 192.

$c.^2$ Abactinal spines very few on disk; normally no pedicellariae present. *inops* Fisher, p. 191.

$b.^2$ Central spine of abactinal plates present on ray only, frequently very few and confined to the outer attenuate portion of the arm; pedicellariae on abactinal, inferomarginal, actinal intermediate plates, and sometimes also on the superomarginals, and over the intermarginal sutures.

c^1. Papularia small, with about 25 pores which do not extend farther than the middle of the third superomarginal; superomarginals narrow, about twice as long as wide proximally; furrow spines 10–12; oral spines 11–13; the innermost spine flattened, the tip of 1 of a pair grooved or incipiently bifid; second not conspicuously widened; first adambulacral plate with a single subambulacral spine. *diomedeae* Fisher, p. 200.

$c.^2$ Papularia large, with 35 to 80 pores, which in full-grown specimens extend to opposite the sixth or seventh superomarginals; superomarginals wider, distinctly less than twice as long as broad; furrow spines in largest specimen 9 or 10; in small and medium sized examples about 8; oral spines 8 to 10, the inner 2 broad, spatulate, with truncate often crenulate tip; first adambulacral with 2 subambulacral spines. *gazellae* Studer, p. 196.

a^2. No enlarged central spine on abactinal plates.

$b.^1$ Disk medium; 1 superomarginal spine throughout series; subambulacral spine prominent.

$c.^1$ Very large papularia with 35 to 80 pores; inferomarginal spines long and rather slender; inferomarginal spinelets slender, papilliform; usually numerous inferomarginal fasciculate pedicellariae; 15 to 15½ adambulacral plates to first 10 inferomarginals; 1 suboral spine. *gazellae* Studer, p. 196.

$c.^2$ Very small papularia with about 10 pores; inferomarginal spines short and thick; inferomarginal spinelets squamiform on center of plate; normally no fasciculate pedicellariae on the actinal surface of inferomarginals; 17 adambulacral plates to first 10 inferomarginals; 2 suboral spines_________________________________*ludwigi* Fisher, p. 203.

$b.^2$ Disk large; distal superomarginals with transverse series of 3 prominent spines; actinal interradial areas rather large; pectinate pedicellariae on proximal inferomarginals and on actinal intermediate plates; subambulacral spine rather small_________________*triplacanthus* Fisher, p. 205.

CHEIRASTER INOPS Fisher.

Cheiraster inops FISHER, 1906, p. 1043, pl. 10, fig. 4; pl. 17, fig. 2.—KOEHLER, 1909, p. 15.—LUDWIG, 1910, pp. 445, 446.

Notes on Philippine specimens.—The largest specimen exceeds the type in size. R=118 mm., r=16.5 mm., R=7.1 r; breadth of ray at base, 19 mm., at third inferomarginal, 15 or 16 mm. It is smaller than Koehler's specimen, in which R=130 mm.

These specimens differ slightly from the type, but the difference in size must be taken into consideration. The central spine of the paxillae is found scattered rather widely over the disk, where it is of inconspicuous size. On the ray they are larger and more numerous than on the disk, and more numerous in the larger of the 2 specimens, being found on the lateral as well as on the median portions of the area. The furrow spines vary from 7 to 9, and the subambulacral spine is prominent and curved slightly. The plates of the outer third or two-fifths of ray have a small subambulacral spinule between the principal spine and the furrow margin, and the first 2 or 3 plates may also have a similar spinule (but sometimes placed external to the large one). On the rest of the ray a slightly enlarged subambulacral spinelet usually stands aborad to the large spine. A number of spinelets stand merely on the edge of the plate and form a cordon spaced from the base of the large spine. There are 13 to 14, rarely 12 or 15, adambulacrals to the first 10 inferomarginals. The actinal intermediate plates are covered with spaced, pointed, slightly swollen spinelets, with usually an enlarged central spine. I do not think the presence or absence of the enlarged spine is of much importance for classificatory purposes.

The specimen from station 5111 has 2 small pectinate pedicellariae—almost rudimentary—in one interradial area; otherwise pedicellariae are absent.

The papularium is flat and distally strongly two-lobed. I am unable to trace a tendon from the dorsal muscles, but the tenth and eleventh ambulacral ossicles are slightly higher than the preceding. It is probable that a very rudimentary tendon is attached to their outer ends.

Type.—Cat. No. 21157, U.S.N.M.

Type-locality.—Station 3865, Pailolo Channel between Molokai and Maui, Hawaiian Islands, 256–283 fathoms, fine volcanic sand and rocks; bottom temperature 44.8° F.

Distribution.—Hawaiian Islands, Philippine Islands, Indian Ocean south of Ceylon; bathymetrical range, 256 to 684 fathoms.

Specimens examined.—Two:

Station 5111, Balayan Bay, Luzon, 236 fathoms.

Station 5445, north coast of Samar, 383 fathoms, green mud, sand; bottom temperature 44.3° F.

CHEIRASTER NIASICUS Ludwig.

Plate 47, fig. 2; plate 54, figs. 4, 4*a*.

Cheiraster niasicus LUDWIG, 1910, p. 456.

Diagnosis.—Differing from *Cheiraster inops* in having pectinate pedicellariae on the actinal intermediate plates and usually also fasciculate pedicellariae on the inferomarginals, as well as more numerous abactinal spines on the disk. Abactinal spines variable in number, but scattered all over disk and rays; superomarginals encroaching conspicuously upon actinal surface; inferomarginals with more than 1 accessory spinule proximally, adambulacral furrow spines 8 to 10. In a large specimen R=95 mm., r=12.5 mm., R=7.5 r; breadth of ray at base, 15 mm. (Station 5447.)

Description.—Abactinal spines variable in number, but more numerous than in *Ch. inops* and scattered all over the abactinal area; numerous in the type. Larger paxillae of disk with 10 to 15 short, pointed spinelets in 1 or 2 circles around the spine. On the ray the paxillae are spaced (one-half to their own diameter apart) and have 5 to 9 spinelets. No abactinal pedicellariae.

Superomarginal plates with the dorsal surface broader than long proximally (in large specimens) and longer than broad distally; in small specimens they form a conspicuous border to the abactinal area, but the plates are narrower than long. Each plate is tumid, and separated from the adjacent plates by a prominent, oblique groove. Each bears nearer the outer than inner margin a sharp tapering spine equal to the length of 1.5 to 2 plates. The first 2 spines are shorter. General surface of plate covered with upright spaced spinelets similar to those of the paxillae. Superomarginals 48 in largest specimen (that used for description).

Inferomarginals also tumid actinally and laterally; and proximally wider than long, the actinal surface becoming narrower distally. There is a stout, tapering, sharp, lateral spine equal to a little less or a little more than the length of 2 plates. In addition to this there are proximally 2 or 3 unequal accessory spinules below or internal to the principal spine, these gradually reduced to 1 distally which may be one-half to three-fourths the length of the principal spine. In small specimens only 1 accessory spinule is present. The plates are covered with short spinelets, several of which near the lateral spines are slightly enlarged.

Actinal intermediate plates extending, in the largest specimen, to the third inferomarginal and covered with numerous slightly spaced subpapilliform, pointed spinelets, with usually also 1 or 2 central enlarged spines (except in some young specimens, station 5619).

Furrow spines 8 to 10, usually 9 or 10, but in small specimens sometimes 7, and similar to those of *Ch. inops*. Along the adoral transverse margin of the plate are 3 or 4 spinelets and a slightly larger spinelet stands aborad of the subambulacral spine, which is prominent and carried on a central prominence of the plate. On the outer third of the ray the accessory spinelet moves inward and stands between the subambulacral and the aboral, inner corner of the plate. It is lacking in small specimens, except sometimes close to the end of the ray. The number of adambulacrals to first 10 inferomarginals, 14 or 15.

Mouth plates with about 8 marginal spines, the inner two considerably enlarged. One prominent suboral spine is present near the inner end of the plate, and a series of about 7 or 8 spinelets follows the margin of median suture. Several spinelets are present on the outer part of the plate between the adambulacral margin and median suture. The enlarged subambulacral is sometimes absent, or poorly developed (station 5619, small specimens).

Pedicellariae are present: (1) Rarely on the vertical (interradial) suture between the first superomarginal plates of either ray (station 5619); (2) in a similar position on the inferomarginals (same 2 specimens, but not in all interradii); (3) fasciculate pedicellariae on a variable number of inferomarginals beyond the second or third, and near inner edge of plate. There are 8 to 12 on either side of the ray in the largest specimen, and sometimes 1 or 2 spinelets belong to an adjacent adambulacral plate. Each pedicellaria, which is circular, is composed of 5 to 7 sharp spinelets. These pedicellariae are lacking on small specimens from stations 5626 and 5658, and few on a specimen from stations 5624, 5618, and 5445. (4) Two or 3 pectinate pedicellariae (sometimes as many as 6) are present in each interradial area. Rarely a pedicellaria is fasciculate and confined to 1 plate (stations 5447, 5619).

A small specimen from station 5658 and 2 from station 5348 (the largest having R equal to 21 mm.) lack pedicellariae. There are 14 adambulacrals to the first 10 inferomarginals, and at most only 2 papular pores to each papularium. These specimens are placed here rather than under *Pectinaster hylacanthus* because the superomarginal plates encroach conspicuously upon the abactinal surface and the superomarginal spines are situated near the outer part of the plate. In *P. hylacanthus* the superomarginals are confined to the side of the ray. The specimens are classed with *niasicus* rather than with *Ch. inops* on account of the more numerous abactinal spines. They may really be small examples of *Ch. pilosus* Alcock. It is not possible, as a rule, to be entirely certain of the identification of young *Cheiraster* and *Pectinaster*. The specimens just mentioned do not exhibit any characteristics which would place them unequivocally in either genus, and without the adults for comparison it would not be possible to say whether they belong to *Pectinaster* or *Cheiraster*. As to the specific identification, it must be considered only as probable. *Cheiraster pilosus*, *Ch. inops*, and *Ch. niasicus* are very closely related. I am not certain of the characters of *Ch. pilosus*. Alcock describes and figures several accessory inferomarginal spines, while Ludwig (1910, p. 456) writes that there is only 1 (in contradistinction to *inops* and *niasicus*, which have several). Alcock figures and not very definitely describes actinal intermediate pedicellariae, indicated also by Ludwig (1910). Koehler (1909, p. 13) places *pilosus* in *Pontaster* (as restricted by Perrier), thus indicating that pedicellariae are absent.

In the largest specimen there are 38 spores to the papularium examined, distributed in 4 irregular longitudinal rows. The papularium is bifurcate distally.

A very small, rudimentary tendon from the dorsal muscle joins the outer end of the tenth ambulacral ossicle, which does not differ in form from its neighbors. This tendon can be seen only with difficulty.

Type-locality.—Not stated (unless the name refers to Nias Island, off Sumatra).

Distribution.—Gulf of Boni, Celebes, and Molucca Islands to Palawan Passage and Luzon, Philippine Islands; "Indian region" (Ludwig).

Specimens examined.—Twelve.

Specimens of Cheiraster niasicus examined.

Station.	Locality.	Depth. (fathoms)	Nature of bottom.	No.	Bottom temperature.
					° *F.*
5348	Palawan Passage, lat. 10° 57′ 45″ N.; long. 118° 38′ 15″ E.	375	Coral sand	2	56.4
5445	North coast Samar	383	Green mud, sand	1	44.3
5447	Lagonoy Gulf	408	Green mud, coral	1	42.3
5618	Molucca Passage	417	Gray mud	1	....
5619	.....do	435	Fine gray sand, mud.	4	....
5624	Between Gillolo and Makian Islands, Molucca Islands.	288	Fine gray sand	1	....
5626	Between Gillolo and Kayoa Islands	265	Gray mud, fine sand.	1	....
5658	Gulf of Boni, Celebes	510	Gray mud	1	41.2

Remarks.—This species differs from *Ch. pilosus* in having longer and slenderer rays, especially distally (R=7.5 r as against 6+ in *pilosus*); and in the adult stage in having inferomarginal fasciculate pedicellariae, and rather fewer abactinal spines.

The specimens from stations 5618 and 5619, perhaps, belong to a distinct variety. They have only 1 accessory inferomarginal spine, and the dorsal surface of the superomarginals is narrower than in any of the other examples. It is these specimens which have a subcircular pectinate pedicellaria on the interradial marginal sutures, as described for *Ch. trullipes* (Sladen). In *trullipes*, however, there are no enlarged central paxillar spines, the paxillae are much smaller, and actinal intermediate plates are absent (due to immaturity, very probably). The specimens from stations 5618 and 5619 have also actinal intermediate and inferomarginal pedicellariae, 8 or 9 furrow spines, 8 oral spines, and the abactinal spines not very thickly scattered all over the abactinal surface. The papularium contains 14 or 15 pores, and is a trifle swollen, but it is slightly two-lobed. A curious circumstance is that these specimens closely resemble examples of *Pectinaster hylacanthus*, with which they were at first confused, the two forms having been taken at the same dredge haul. They are distinct, however, and really belong to different genera, although the presence in both of inferomarginal fasciculate pedicellariae is misleading. In *hylacanthus* the superomarginals are more lateral in position, and the spine is nearer the upper edge of the plate. The pedicellariae have blunter, broader jaws, and the actinal intermediate pedicellariae of *niasicus* are generally pectinate—that is, on two plates, although subcircular in shape. The papularium of *hylacanthus* is more swollen, and when examined from the inner side the plates are seen to be more modified, especially in the center of the area, and the area itself shows no sign of being two-lobed. The superficial similarity of the two species is, however, very striking.

Ludwig's original diagnosis of *Cheiraster niasicus* is very brief and incomplete—scarcely more than enough to technically fix the name. There are many points about which more information would be desirable: for instance, the dimensions, proportions of marginal plates, and minor details of ornamentation. But since a number of major characters of the present species nearly or quite agree with the diagnosis of *niasicus*, I have given Ludwig's name to the *Albatross* specimens. The description was based largely on a specimen from Station 5447, Lagonoy Gulf, 408 fathoms.

CHEIRASTER GAZELLAE Studer.

Plate 50, figs. 1–3; plate 51, fig. 1; plate 52, fig. 1; plate 54, figs. 3, 3*a*; plate 56, figs. 1, 2.

Cheiraster gazellae STUDER, 1883, p. 129; 1884, p. 50, pl. 4, fig. 8, *a*, *b*, *c*.

The specimens listed below belong to a corner of the genus in which the features relied upon to differentiate species are subject to considerable variation. The species of this section look alike, so that the characters sought to separate them are difficult to handle because they concern minute, or perhaps subtle, points of structure which do not come out well in photographs, and which may even escape the notice of a conscientious observer. The specific groups, into which this section of *Cheiraster* has been divided, must, therefore, be considered as experiments. They may not stand the test.

Ludwig (1910, p. 456) states in his key that the enlarged central spinule which occurs on the abactinal plates of several species, notably *pilosus*, *niasicus*, and *inops*, is lacking in *gazellae*. He appears not to have examined specimens personally, judging by a list of species, given on page 436, which he had examined for the dorsal muscle bands. There is no evidence from Studer's figure that the distal abactinal plates lack the small central spinule (such as characterizes *Ch. snyderi*), for the reason that the ray is recurved and the terminal third is hidden, and the figure is not large enough to show such spines. Studer does not mention them. It must be remembered that Studer's type was small, R measuring only 61 mm.

In all the large specimens listed below these spinules are present. In 3 large examples from station 5538 the maximum of variation is present. In one the inconspicuous central spinules are found only on the terminal attenuate sixth of the ray and are few in number. In the other 2 specimens they extend unevenly to the papularia. In a large specimen from station 5122 the spinules are present only near the tip and are few in number. Numerous small examples (R 45–60 mm.) from station 5388 either lack the spinules or have a few on the terminal third or fourth of the ray. At best they are inconspicuous. There are a few other differences which will be pointed out the course of the description.

Diagnosis.—Closely related to *Ch. snyderi* Fisher, but differing in having in the adult longer marginal, subambulacral, and furrow spines, larger papularia with more numerous pores, almost obsolete abactinal central spinules, slightly more numerous furrow spines; pedicellariae numerous on actinal intermediate plates, on inferomarginals, abactinally (very variable), and intermarginally; in large specimen 15 or 15½ and in small specimen 14, adambulacral plates corresponding to first 10 inferomarginals. Large example from station 5122 measures: R=120 mm., r=15 mm., R=8 r; breadth of ray at base, 19 mm.

Description.—As compared with *Ch. snyderi*, the spinelets of the paxillae are a little longer. A large paxilla has about 20 and a medium-sized one about 10 papilliform, pointed spinelets in a floriform group. Sometimes the central spinelet is a trifle longer than the others. The enlarged central spinule, as stated above, varies in occurrence, being usually confined to the outer third to sixth of ray, but occasionally straggling as far as the papularium, and sometimes, especially in small specimens, being entirely absent. The papularia are large, bifid distally, the total length being about two-thirds the diameter of disk. In a large specimen (station 5122) there are about 85 pores to an area, and in a small example (station 5388), about 42; in *Ch. snyderi* there are about 30, and the papularium is about r in length. The outer end of the papularium is opposite the sixth or seventh superomarginal in *gazellae;* opposite the end of the third in *snyderi.*

Abactinal pectinate pedicellariae usually rare. In some specimens from station 5388 they are very abundant. The larger consist of 7 to 9 sharp spinelets in 2 curved combs (each on a separate plate). These spinelets are conspicuously larger than the other spinelets and the pedicellariae occur on the disk and nearly to tip of ray. Other examples from the same station have only a few abactinal pedicellariae, while in still others they may be all but absent.

Superomarginals with a distinct dorsal surface, the spine being on the lateral face, spaced from the inner edge and in length equal to 2 to 3 plates. It is a little longer than in *snyderi*. Below the principal inferomarginal spine, which equals in length 2 to 3 plates, is a transverse row of 2 secondary spines, the median often over half as long as the lateral spine; or there may be 3 or 4 spaced secondary spines forming an irregular group. The inferomarginal armature is more prominent than in *snyderi*, where the principal spine scarcely ever equals 2 plates in length. At the base of the ray there is some irregularity in the number and position of the secondary spines.

Furrow spines long, slightly curved, commonly 9 or 10, sometimes 11, distally. The ends are usually blunt or truncate and slightly flattened. The subambulacral spine is prominent and often slightly curved and equal to 2 plates in length. On the outer part of ray a second smaller spine is present between the main spine and the furrow margin. As many as 10 to 15 spinelets stand on the edges of the plate and between the subambulacral spine and outer edge of plate. Two or 3 are conspicuously larger than the others, especially 1 near or on the aboral margin, which far along the ray moves inward and becomes the accessory spinule. The first 2 or 3 plates usually have 1 or 2 accessory subambulacral spines of conspicuous size, but beyond this point there is but 1 spine and the 2 or 3 enlarged spinelets spoken of above, until the outer part of the ray is reached when a second is regularly present.

Marginal mouth spines 8 to 10, the inner 2 broad, truncate, spatulate. There is one conspicuous suboral spine near the margin and 15 to 20 suboral spinelets, those near the inner end the longest but all conspicuously shorter than the spine.

Pedicellariae are present: (1) Sparingly on the abactinal surface. (2) A few between the superomarginal and inferomarginal plates. (3) Subcircular fasciculate pedicellariae near the inner edge of the inferomarginals, often with 1 or 2 of the spines standing on an adjacent adambulacral plate. There are usually 6 to 8 sharp, tapering jaws to each, and they extend upward of three-fourths the length of the ray, being absent usually from the first 2 plates. There are 1 or 2 to a plate and they occupy the same position as do the pedicellariae in *Pectinaster mimicus*, except that here the jaws are slenderer and sharp. (4) Upward of 12 prominent pectinate pedicellariae to each actinal interradial area. In the largest specimens the actinal plates extend to the fourth inferomarginal (sometimes the third) and bear in addition to the pedicellariae numerous spaced spinelets and usually an enlarged spinule. The latter is not at all constant in occurrence. There are very few, or none, in some of the areas in small specimens (station 5388), while one or more areas will have at least a few developed.

In the large specimen from station 5122 the dorsal muscle of each side sends 2 very inconspicuous tendons to join the upper and outer end of the twelfth and thirteenth ambulacral ossicles. It is consequently inaccurate to state that the muscle is not attached to the ambulacral ossicles in *Cheiraster*. There is, however, no specialized knob as in *Luidiaster dawsoni*. My key (1911*d*, p. 120) should read "ambulacral ossicle without specialized crest for attachment of tendon of dorsal muscles; tendons very inconspicuous." In the specimens of *Ch. snyderi* and *Ch. inops* which I examined for this feature, the tendons can not be seen, possibly because the specimens were partly dried. Drying does not destroy the tendon in *Luidiaster*, nor in typical *Pectinaster*.

Variations.—The principal variations have already been noted. Special mention should be made of specimens from station 5388, which have very numerous pedicellariae, especially on the abactinal surface. These abactinal pedicellariae, however, are very variable in number. There are 8 or 9 furrow spines, a trifle broadened at the tip, which may be rounded or truncate. The first plate has 2 subambulacrals, the others have 1, until the outer part of the ray is reached, when there are usually 2, the smaller being next to the furrow series. The marginal mouth spines are 8 and the inner is much enlarged, flattened, broader at the truncate tip than at base. The second spine is a little shorter, and about three-fourths the length of the inner. The remaining 6 are subequal, two-thirds to three-fourths as long as the second oral spine, and very similar in every way to the first adambulacral furrow series, though sometimes individually a trifle broader. The inferomarginal and superomarginal spines are markedly longer than in *Ch. snyderi* of nearly equal size. In these specimens the papularia are much larger than in *snyderi*, extending to the end of the fifth or middle of the sixth superomarginal plate. The papulae are about 40 to 45 in these small specimens.

Type-locality.—Lat. 18° 5′ 2″ S.; long. 116° 3′ 8″ E. (off northwestern Australia), 195 fathoms, gray mud.

Distribution.—Northwestern Australia; Mindoro and southern Luzon, 195 to 256 fathoms, bottom temperature 51.4° to 53.3° F.

Specimens examined.—One hundred and eleven from the following stations:

5122. East coast of Mindoro (vincinity Malabrigo Light), 226 fathoms, green mud; 9 specimens.

5388. Between Burias and Luzon (vicinity Bagatao Island Light), 226 fathoms, soft green mud, bottom temperature 51.4° F.; 99 specimens.

5538. Between Negros and Siquijor, 256 fathoms, green mud, sand, bottom temperature 53.3° F.; 3 specimens (large).

CHEIRASTER DIOMEDEAE Fisher.

Plate 47, fig. 1; plate 54, figs. 5, 5*a–c*.

Cheiraster diomedeae FISHER, 1917*b*, p. 90.

Diagnosis.—Rays 5, long, slender, with narrow marginals carrying 1 superomarginal and usually 2 inferomarginal spines; abactinal plates, with 10 to 15 spinelets on disk, and on ray usually 2 to 7; enlarged central spinules scattered on outer half or two-thirds of ray; adambulacral furrow spines 10 to 12; 1 subambulacral except on outer part of ray, where there are 2; 11 to 13 oral, and 1 prominent suboral spine. Papularia small, with about 25 pores, which do not reach farther than opposite middle of third superomarginal. Pectinate pedicellariae on the abactinal surface, between the proximal superomarginals, over the intermarginal suture, on the actinal intermediate plates; fasciculate pedicellariae on the actinal surface of inferomarginals. Related to *Ch. snyderi.* R=86 mm., r=10 mm., R=8.6 r; breadth of ray at base (between first and second superomarginals, 10 mm.; at middle of ray, 5 mm.

Description.—The groups of spinelets of the abactinal plates are slightly spaced—usually about one-third the diameter of the pseudopaxilla, which consists, on the disk of 10 to 15 tapering rough spinelets, the 3 to 5 central variable in length, but ordinarily longer than the peripheral. Some of them have a short central spinule overtopping the rest, but not long enough to rank as an enlarged central spine, the latter occurring on the outer half or two-thirds of the ray, where the distinctly spaced pseudopaxillae have 2 to 7 short delicate spinelets. Only a relatively few along the radial area have an enlarged central spine. This is slender, rough, pointed, and variable as to length, being proximally 3 to 5 times the length of the peripheral spinelets, and distally upward to 10 times. Some of the larger spines have 9 or 10 peripheral spinelets. Pectinate pedicellariae are scattered on the disk and base of rays. They consist of 2 combs of 3 to 5 pointed spines, 2 to 4 times longer than the ordinary spinelets of the same plate. The 2 combs are on adjoining plates, and appear to be a little less specialized than in *Ch. gazellae*, inasmuch as the plate is scarcely different from the other except for the presence of the slightly curved comb of sharp spines. Some combs do not have a vis-à-vis.

The papularia are small, with about 25 pores in 4 rows, the distal end being scarcely two-parted. The papularium extends to opposite the end of the second or the middle of the third superomarginal plate, its total length being 6 to 7 mm. and breadth 4 mm., or, respectively, 0.6 to 0.7, and 0.4, the minor radius. The small papularium alone will readily separate this species from *gazellae*, in which the pores of even small specimens are over 35 in number.

The superomarginals, 40 in number, are narrow abactinally, the extreme length being about twice the abactinal breadth (2.5 mm.: 1.25 mm.), and the long single spine is lateral in position. This spine is quite short on the first plate, but increases in length up to the fifth, where it is exactly 2 plates in length; this length is maintained for a few plates, then the spine decreases gradually and a little more rapidly than the decrease in the length of the plates, for on the outer half of ray it is 1.5 plates in length. The first 3 or 4 transverse superomarginal sutures have a small pectinate pedicellaria. The general surface of the plate is covered with very short, slender, delicate spaced spinelets, a little longer near the base of spine. No accessory spinules.

Inferomarginals rather narrow actinally but very tumid laterally, with one slender, tapering, sharp, lateral spine, ordinarily a little slenderer and shorter than the corresponding superomarginal spine on the proximal third of ray; but beyond that point the spine decreases very slowly in size, while the superomarginal decreases much more rapidly. The inferomarginal spine is 1.5 to 2 times the length of the superomarginal on the outer third of the ray and about 2 to 2.25 plates in length. Just below the principal spine is a second one, half to two-thirds its length, while on the proximal fourth of ray is a third (and sometimes beside it a fourth) about one-half or two-thirds as long as the inner border of the plate. The general surface of the plate is covered with well-spaced spinelets similar to those of the superomarginals. With the exception of the first or first 2 inferomarginals and those of the terminal third of ray (about the last 20), the actinal surface of each plate bears 1 or 2 conspicuous, circular, fascicular pedicellariae with 5 to 8 sharp, tapering teeth. In addition, on the longitudinal *intermarginal* suture, to nearly every pair of supero-inferomarginals beyond about the tenth, is a small pectinate pedicellaria with 3 to 5 slightly modified spinelets to each comb. The 2 combs meet over the intermarginal suture and may occur up to the last marginals.

Corresponding to first 10 inferomarginals, 16 adambulacral plates. The latter are distinctly spaced and have a semicircular, prominent furrow margin bearing at the base of ray 10, increasing on outer part of ray to 12 slender, round-tipped, slightly curved spines, of which the median 6 or 7 are the longest. On the actinal surface of plate is a single slender, tapering, sharp, slightly curved spine about as long as the inner border of the adjacent inferomarginal; on the outer two-fifths of ray a second shorter one is added between the first and the furrow series. There is no second subambulacral spine on the first ambulacral, as in *Ch. gazellae*, *Ch. snyderi*, *Ch. inops*, and *Ch. niasicus.* One or 2 small spinelets stand on either transverse margin of plate and 1 or 2 near the outer margin.

Actinal intermediate plates 16 to 20 to each area and extending to middle or end of second inferomarginal. Each area has 8 to 10 conspicuous pectinate pedicellariae, the largest with 5 or 6, sometimes 7, sharp spines, of the characteristic *Cheiraster* form, to each curved comb. General surface of plates with short, equal, slender, spaced spinelets as long as those of inferomarginals, and to each area 1 to 3 plates have an enlarged spinule.

Mouth plates with 11 to 13, usually 12, marginal spines, the inner truncate or round tipped, broad, and about half as long as the interradial suture between the 2 plates; the next is blunt, about half as broad and three-fourths as long, while the remaining spines resemble those of the first adambulacral. There is 1 suboral spine to each plate, near the free margin and a little nearer the aboral than the inner corner. It is not quite so long as the first subambulacral. There are 18 to 20 short, tapering, pointed spinelets on the convex surface of the plates; 1 just back of the inner marginal spine is intermediate in size between the spinelets and the suboral.

Madreporic body large, with a large plate on its inner side and 7 other rather large plates (in addition to about 3 small) surrounding it. Ridges irregular, transverse, in an interradial direction. It is situated its own diameter from margin.

Type.—Cat. No. 37035, U.S.N.M.

Type-locality.—Station 5512, Iligan Bay, north coast of Mindanao, 423 fathoms, gray mud, fine sand, bottom temperature 52.8° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This species may be distinguished from *Ch. inops* by the absence of scattered, enlarged, central paxillar spines on the disk and by the presence of abundant conspicuous pedicellariae; by the more numerous furrow and oral spines and the absence of a second subambulacral spine on the first adambulacral plate. It may be distinguished from *Ch. niasicus* by its lack of enlarged abactinal spines on the disk, by its very narrow superomarginals (in *niasicus* they are wider than long), by the narrower inferomarginals, more numerous oral and subambulacral spines, and by the absence of a second subambulacral spine on the first plate. The marginal plates of *niasicus* are rather heavy; in *diomedeae* they are relatively small. *Ch. snyderi* seems to be the nearest relative. It has, however, fewer adambulacral and oral spines, a second subambulacral spine on the first plate, broader inferomarginals with longer miliary spinelets, shorter and stouter major marginal spines, and several conspicuous accessory inferomarginal spinules. Further *snyderi* has shorter rays, shorter abactinal spinelets, lacks the conspicuous inferomarginal fasciculate pedicellariae of *diomedeae*, and has a much smaller madreporic body.

The principal differences between *gazellae* and *diomedeae* are as follows: *gazellae* has much more extensive papular areas, with more numerous pores, even in small specimens. Large specimens have about 80 pores and small examples 35 or 40 or even more, according to size. In *diomedeae* there are but 25, or half as many as a similar sized specimen of *gazellae* would have. In *gazellae* there are fewer marginal mouth spines and furrow spines, which are stouter, and the first adambulacral has 2 well-developed subambulacral spines. The abactinal, enlarged spines of the ray of *diomedeae* are more conspicuous and more numerous than usually the case in *gazellae*, although this character is variable and difficult to apply.

CHEIRASTER LUDWIGI Fisher.

Plate 48, fig. 1; plate 49, fig. 2; plate 55, figs. 2, 2*a*.

Cheiraster ludwigi FISHER, 1913*c*, p. 205.

Diagnosis.—Differing from *Ch. gazellae* Studer (as herein understood) in having only about 10 papular pores, and consequently very small papularia, which do not extend beyond the first superomarginal upon the rays; in having short, robust inferomarginal spines, subsquamiform or squamiform central inferomarginal spinelets, no sign of distal abactinal enlarged spinules, and normally no inferomarginal fasciculate pedicellariae; in having 17 instead of 15 to 15.5 adambulacrals to first 10 inferomarginals, and 2 suboral spines instead of 1. Rays 5. R=53 mm., r=9.5 mm., R=5.5 r; breadth of ray at second superomarginal, 9 mm. Superomarginal spine stout, near middle of plate; 1 stout inferomarginal spine and 1 conical accessory spinule below it; adambulacral plates very prominent, meeting in middle of furrow; furrow spines 7 or 8; 1 subambulacral spine (2 on first plate and on distal plates); oral spines 7; suboral spines 2.

Description.—Abactinal plates only slightly elevated, the groups of small, subequal, bluntly pointed or obtuse spinelets distinctly spaced, sometimes more than the diameter of the group. No enlarged central spine anywhere on the abactinal surface. The larger paxillae of disk have 10 to 12 upright or slightly divergent spinelets; the smaller (in the minority) have 5 to 7, or upward of 10. On the ray 5 to 7 slightly slenderer spinelets surround a single central one, or 3 to 5 form a simple group. One or 2 inconspicuous pectinate pedicellariae are present near the anal aperture. Papularia small, 2 parted with about 10 pores, the distalmost being even with a line across the ray between the interradial marginal sutures of either interbrachium. The superomarginals, 25 in number, are longer than broad beyond the fifth, and encroach narrowly upon the abactinal area. the stout, tapering, sharp spine being situated on a slight tumidity at center of plate, and directed horizontally outward. The spines increase in length up to the fourth or fifth, which is about one and one-third times the length of its plate; thence the spines decrease in size gradually with their respective plates. General surface of plate covered with spaced small spinelets similar to those of the paxillae. Sutures between plates prominent and very oblique dorsally. On the interradial suture between the 2 first superomarginals is a prominent pectinate pedicellaria (in one interradius 2, one above the other), with sometimes one, also, between the first and second plates of either ray. On the distal third or fourth of ray, between each pair of supero-inferomarginals, is a pectinate pedicellaria.

For the distance of the first 4 or 5 marginal plates the ray is unusually thick dorsoventrally. Inferomarginal plates tumid, with a stout lateral spine similar to the superomarginal, and below this 1 small spine. On the outer part of the ray the lateral spine is about as long as 2 plates and longer than the corresponding superomarginal. Surface of plates covered with slender, pointed, appressed spinelets, larger, more spaced, and squamiform on the central portion of plate. They are directed away from the inner margin of the plate.

Actinal intermediate areas small, there being but 2 plates in the series between the mouth and first inferomarginal plates, and about 8 for each area, the plates reaching to the middle of the second inferomarginal. Each area has about 4 very prominent semiovoid pectinate pedicellariae with about 5 or 6 blunt, slightly curved spinelets in each comb. The plates also bear spaced subequal spinelets similar to those of the inferomarginals.

Adambulacral plates with a very prominent furrow margin, which touches that of the opposite plate and segregates consecutive pairs of tube feet, the mesial furrow spines standing upright, and the lateral usually also. Furrow spines 8 (sometimes 7), the 3 or 4 mesial terete, untapered, or only very slightly tapered, round-tipped, and upright, similar to the corresponding spines of *trullipes* but longer (equaling the plate in length). On either side of these are 2 slightly tapered, bluntly pointed spines, the lateralmost the shorter. On the center of the plate is a prominent, upright suboral spine (1.5 times length of plate). On the first plate there are 2, and on the distal third of the ray there are regularly 2, the second appearing external to the first, not toward the furrow as in the distal plates of *gazellae*. Six to 8 spinelets form a series around the remaining 3 sides of the plate, usually about 2 standing on either transverse suture margin.

Marginal mouth spines about 7, which decrease in size from the prominent inner tooth to the third spine, which is only half as long.

Then the spines increase slightly, to decrease again, the outer 4 being independently graduated in length toward the 2 mesial (fifth and sixth from inner end of series). Suboral spines 2, in a series parallel to median suture, along which are about 6 spinelets on each plate, in addition to 1 or 2 in line with the suborals.

Pedicellariae, as detailed above occur: (1) Abactinally; (2) between the superomarginals interbrachially; (3) between supero- and inferomarginals on outer part of the ray; (4) on the actinal intermediate plates. One inferomarginal plate of the type has a small fasciculate pedicellaria and one-half of a pectinate pedicellaria on the transverse suture.

Madreporic body situated its own diameter distant from margin, and with a large plate on the adcentral side; striae numerous, fairly coarse.

Type.—Cat. No. 32627, U.S.N.M.

Type-locality.—Station 5660, Flores Sea (lat. 5° 36′ 30″ S.; long. 120° 49′ E.), 692 fathoms, gray mud, sand, bottom temperature 39.2° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This deep-water form differs from *Ch. trullipes* (Sladen) in having a well-developed actinal intermediate area, actinal and intermarginal pedicellariae, larger abactinal paxillae, longer furrow spines, 7 oral spines, and 17 (instead of 15) adambulacrals to the first 10 inferomarginals. *Ch. trullipes* was taken by the *Challenger* west of Luzon, in 1,050 fathoms, blue mud, bottom temperature 37° F. It thus belongs to greater depths and to a lower temperature belt than the Flores Sea species.

This species is named in honor of the late Dr. Hubert Ludwig, whose paper on the Notomyota includes a most useful revision of *Cheiraster.*

CHEIRASTER TRIPLACANTHUS Fisher.

Plate 48, figs. 3, 4; plate 55, figs. 1, 1*a*.

Cheiraster triplacanthus FISHER, 1913*c*, p. 206.

Diagnosis.—Belonging to the *subtuberculatus* group; differing from *subtuberculatus* in having actinal pedicellariae, 7 or 8 furrow spines, longer inferomarginal spines, and especially in having a transverse series of 3 prominent superomarginal spines on the distal half of ray and 1 spine only on the proximal half. Disk large, rays slenderer than in *subtuberculatus*, tapering very gradually from wide interbrachial arcs to a bluntly pointed tip. R=49 mm., r=12 mm., R=4 r; breadth of ray at first superomarginal 14 mm., at third, 8.5 mm. No abactinal spines; papularia large, flat, two-lobed; 1 inferomarginal spine, and proximally 1 or 2 small accessories; 8 or 9 oral, and 1 suboral spine.

Description.—Abactinal area plane, slightly lower than the marginal plates, which form a broad border to the area. Abactinal plates low, slightly convex, not at all paxilliform, and bearing small, prickly, sharp granuliform spinelets. The largest plates, on the papularia, have upward of 10 to 12 peripheral and 2 to 4 central granules, while on the proximal part of the ray 1 or 0 central and 5 to 8 peripheral granules are found. The number of granules decreases toward the end of the ray. On the outer third the number is reduced to 2 or 3, and on the distal fourth, to 1. The groups of granular spinelets are rather uniformly spaced on the disk and proximal half of ray one-third to one-half the width of the group. No enlarged central spines and no pedicellariae.

Papularia large, as long as the first 4 superomarginals and as broad as the length of the first 3, strongly two-lobed. In fact, each papularium is double and joined only at the adcentral end. There are about 80 pores to each.

Anal opening prominent, guarded by 6 plates with longer spinelets than elsewhere on the area.

Superomarginals 22 or 23, encroaching broadly upon the abactinal area, slightly tumid, especially toward ambitus, and separated by prominent, oblique, smooth grooves. The armature is peculiar. About the first 10 plates bear on the rounded margin between the dorsal and lateral facets of the plate a short, stout, pointed tubercle, proximally acorn-shaped, which is shorter there than the length of plate. This spine increases slightly in length and decreases in thickness distad. Beyond the tenth, the plates are more tumid, and each bears a transverse series of 3 subequal, tapering, rough spines which occupy the whole width of the plate. Proximally they are a little longer than their plate, and near the end of the ray are equal to about 3 plates in length. Parallel to the major spines is an adoral series of 3 accessory spinules, while aborally there is an enlarged spinule which often is nearly as large as the major spines, and is associated often with 1 or 2 much smaller spinules. This abrupt transition from 1 to 3 superomarginal spines gives a very characteristic appearance to the armature of the superomarginals, as the distal spines are bent over and usually cover the abactinal area. General surface of plates covered with small widely spaced spinelets similar to those of the abactinal area, which become larger on the low lateral face of plate. The terminal plate is prominent, wider than long, and covered with spines.

Inferomarginal plates slightly tumid, bearing a single lateral, tapering, sharp spine, a little longer than its plate proximally, and regularly and gradually decreasing in size toward end of ray. The first 4 or 5 plates have 1 or 2 small accessory spinules forming a transverse series below the lateral spine. The general surface of plate is covered with spaced, pointed spinelets longest on the well-rounded surface between the ventral and lateral aspect of the plate, and longer than the superomarginal spinelets.

Actinal interradial areas rather large, the distance between the inner edge of inferomarginals and outer end of mouth plates equaling first 3 inferomarginals measured on ambitus, or the distance between interradial suture of marginal plates and the distalmost intermediate plate. Each plate bears a few subequal, spaced, papilliform spinelets. Each interradial area bears 6 to 8 subcircular pectinate pedicellariae, with 3 to 6 stout, sharp jaws. Sometimes a pedicellaria consists of only 1 comb.

Adambulacral plates with a semicircular furrow margin bearing a fan-shaped group of 7 or 8 slender spines, slightly shorter than their plate, the 2 or 3 median sometimes slightly shorter than those spines immediately to either side. There is 1 subambulacral spine about as long as its plate, and proximally 1 to 3 spinelets form a more or less evident longitudinal series with the above. Distally the subambulacral spine is not prominent and is accompanied by 1 to 3 spinelets only slightly smaller and all subequal to the furrow spinelets. Seventeen (or 16.5) adambulacrals correspond to first 10 inferomarginals.

Mouth plates broad, with 8 or 9 marginal spines, the inner the longest, tapering, bluntly pointed, the rest subequal to the adambulacral furrow spines and decreasing a trifle in length at outer end of series. About midway between inner and outer ends of plate is a short conical suboral spine, about as long as the subambulacral. Six or 7 spaced spinelets follow the median suture margin and about 3 the margin adjacent to first adambulacral plate.

In addition to the actinal intermediate pedicellariae a small pectinate pedicellaria occurs irregularly ventrally on the transverse suture, between any of the first 5 inferomarginals, but never between all of them.

Madreporic body small, with few coarse striae, and situated twice its diameter from the inner margin of the superomarginal plates.

Type.—Cat. No. 32628, U.S.N.M.

Type-locality.—Station 5651, Gulf of Boni, Celebes, 700 fathoms, green mud; bottom temperature, 38.7° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This *Cheiraster* has a very different appearance from any others herein listed. The transverse series of 3 prominent spines on the distal marginals is very characteristic and will serve to distinguish the species from *Ch. subtuberculatus* and *Ch. granulatus* (see Ludwig, 1910, p. 456). The presence of only 1 prominent inferomarginal spine and of inferomarginal pedicellariae are additional differences separating *triplacanthus* from *granulatus*. *Ch. subtuberculatus* was taken by the *Challenger* at station 164, off the coast of Australia, east of Sydney, 950 fathoms, green mud; bottom temperature 36.5° F.

Genus BENTHOPECTEN Verrill.

Benthopecten Verrill, Amer. Journ. Sci. and Arts, vol. 28, 1884, p. 218 (footnote).—Ludwig, 1910, p. 464 (part).—Fisher, 1911*d*, p. 142. Type, *B. spinosus* Verrill.

Parachaster Sladen; 1885, p. 610.—Ludwig, 1910, p. 462 (part). Type, *P. pedicifer* Sladen; figure.

KEY TO SPECIES OF BENTHOPECTEN HEREIN DESCRIBED.

a^1. Actinal plates with a single spinelet, the long spines of disk graduated in length into spinelets of ray ------------------------ *B. moluccanus*, p. 208.

a^2. Abactinal plates with more than 1 spinelet, at least on disk; the comparatively few prominent spines of ray not graduated in length into those of disk.

  b^1. Abactinal plates of ray with upward of 5, or even more, spinelets; odd interradial superomarginal spine not unusually long (equal in length to first 1.5 to 2 superomarginals); short accessory superomarginal spines; inferomarginal pedicellariae on outer part of ray -- *B. polyctenius*, p. 211.

  b^2. Only 1 or 2 spinelets to each abactinal plate of ray; odd interradial superomarginal spine very long (equal in length to first 4 or 5 superomarginals); no accessory superomarginal spines; no inferomarginal pedicellariae on outer part of ray ------------------ *B. styracius*, p. 213.

BENTHOPECTEN MOLUCCANUS Fisher.

Plate 53, fig. 1; plate 55, figs. 5, 5*a*–*b*.

Benthopecten moluccanus, 1913*c*. p. 207.

Diagnosis.—Differing from *B. huddlestonii* in having only 2 inferomarginal and 2 subambulacral spines, and from *B. acanthonotus* in having a larger adambulacral furrow comb (with 7 to 9 spines), pedicellariae between the distal inferomarginal plates, very few or no accessory abactinal spinelets, a more restricted papular area, and inferomarginal spines which are subequal proximally. R=80 mm., r=8 mm., R=10r; breadth of ray at base, about 10 mm. Disk small, rays slender and very flexible. Abactinal plates with a single spine, those of disk graduated in length into spines of rays; superomarginals with 1 and inferomarginals with 2 spines; subambulacrals, 2; furrow spines, 7 to 9; oral spines variable, 5 to 8; suborals, 3 to 5; abundant abactinal pedicellariae on disk and variable on rays; inferomarginal pedicellariae in interbrachium and an outer part of ray; actinal intermediate pedicellariae often present.

Description.—Abactinal plates each with a single, slender, thorny spine, those of the disk long and bristling (4 mm., or equal in length to 1.5 proximal superomarginals). These shorten gradually from center of disk to base of ray, as in *B. huddlestonii*, the spinelets of ray being well spaced and about 1 mm. long. A few plates have 1 or 2 minute spinelets in addition to the above. Numerous pedicellariae, with 3 to 5 minutely thorny spinelets in each comb and with 2, 3, or 4 combs to each pedicellaria, are scattered over disk and form an interrupted series along either side of ray near the marginal plates, for about half the length of ray. The pedicellariae are very variable in number on the ray. In the cotype there are 15 or 16 in each series; in the type about 3 to 5; in small specimens (R=up to 50 mm.) the pedicellariae do not extend beyond the papular area.

Papulae are distributed over disk and along ray as far as the beginning of the third superomarginal plate. The end of the area is bilobed.

Superomarginal plates, subelliptical, longer than high, confined to side wall of ray and with a long slender spine on the middle of the upper margin, below which is a much shorter and slenderer rather inconspicuous spinule and a second just aborad. The principal spine is longest in the fourth, fifth, and sixth plates, there equaling the length of 1.75 superomarginals (6 to 7 mm.). The surface of the plate is bare, except for 1 to 3 minute spinelets, near the adoral margin of the plate. Interradial plate a little over 1.5 times as high as the adjacent first superomarginal, bearing at its upper end a stout, long, sharp spine (7 to 10 mm. long, or longer than r) and 3 accessory spinules about 3 mm. long. Terminal plate broader than long, with a broad notch adorad, and the surface covered with numerous prominent spinules.

Inferomarginals slightly in advance (aborad) of the superomarginals, and with 2 subequal spines, a little smaller proximally than the corresponding superomarginal spines; distally the upper spine is considerably longer than the superomarginal spine, while the lower is conspicuously shorter than its companion. Pedicellariae occur between the inferomarginal plates irregularly in the interbrachium, and also on the outer half or two-thirds of rays. The occurrence is very variable even on different rays of the same example. Small specimens may lack the distal pedicellariae, and the interbrachial are lacking in a specimen, nearly as large as the type, from station 5619.

The type has 6 actinal intermediate plates forming a single series. The plates have a subcentral slender spine and 2 or 3 minute spinelets, but no pedicellariae. In the cotype there is a pedicellaria in 2 interradii. Three specimens from station 5619 have the pedicellariae and 4 lack them. One is interesting in having the pedicellariae between the odd inferomarginal and the intermediate plates.

Adambulacral plates with 7 furrow spines on the first few plates, then 8 or sometimes 9. Subambulacral spines 2, in an oblique transverse series. Nineteen or 20 plates correspond to the first 10 inferomarginals.

Mouth plates with 5 to 8 furrow spines, the inner much enlarged, the second slightly less so. Suboral spines 3 to 5.

Madreporic body convex, prominent, touching an odd superomarginal; striae radiating; ridges rather fine.

Variations and young.—In specimens of the same size as the type and cotype variation is found in the number of abactinal pedicellariae of the rays; in the occasional presence of 1 or 2 minute spinelets in addition to the regular spine of the abactinal plates; in the number of inferomarginal pedicellariae; presence of actinal interradial pedicellariae; in the number of oral spines (5 or 6 in type, 8 in cotype); in the number of suboral spines (3 in type, 5 in cotype); length of odd interradial superomarginal spine (7 or 8 mm. in type, 10 mm. in cotype).

Small examples (R=30 mm.) have relatively very prominent interradial superomarginal spines, lack abactinal pedicellariae on rays, have very small or no accessory superomarginal spinules, have as few as 4 or 5 furrow spines, 4 oral spines, and 3 suboral spines. Specimens of intermediate size have 6 or 7 furrow spines, but the number of oral and suboral spines varies in specimens of the same size just as in the adult. The same is true of the actinal intermediate pedicellariae.

There is a very young specimen from station 5619, having R 9 mm. The odd interradial superomarginal spines are 5 mm. long; furrow spines 4 or 5, oral spines 6; no pedicellariae.

Type.—Cat. No. 32629, U.S.N.M.

Type-locality.—Station 5618, Molucca Passage (lat. 0° 37′ N.; long. 127° 15′ E.), 417 fathoms, gray mud; 2 specimens.

Distribution.—Known only from Molucca Passage.

Specimens examined.—Nine; in addition to the type, 7 from station 5619, Molucca Passage, near type-locality, 435 fathoms, fine gray sand and mud.

Remarks.—This species differs from *B. huddlestonii* Alcock in having abactinal pedicellariae, only 2 inferomarginal spines, 2 subambulacral spines, and a less complete series of inferomarginal pedicellariae. Although the type of *moluccanus* is much smaller than that of *B. huddlestonii*, there are as many, or even 1 more, furrow spines. In Ludwig's key to the species of *Benthopecten* (1910 p. 465) *B. moluccanus* would occupy a position just after *B. huddlestonii*, with a coordinate subhead reading: inferomarginal plates with 2 spines; adambulacral plates with 7 to 9 furrow and 2 subambulacral spines; mouth plates with 5 to 8 oral spines.

B. moluccanus differs from *B. semisquamatus* (Sladen) and *B. antarcticus* (Sladen) in having pedicellariae and more numerous furrow spines. It differs from *B. spinosus* Verrill in having pedicellariae, in having only 2 (and larger) inferomarginal spines, smaller disk, smaller actinal intermediate areas, and more numerous long, abactinal disk spines, which are graduated in length into those of the ray, not abruptly larger as in *spinosus*. *B. spinosus* is of a much stouter habit, as is also *B. mutabilis*, which does not at all resemble *moluccanus*, having the abactinal spines abruptly larger in the middle of the disk. *B. acanthonotus* differs in having a shorter furrow comb with 4 to 5 spines, several prominent accessory inferomarginal spinules and 1 to 6 accessory spinelets in connection with the abactinal spines of disk, and in having the inferomarginal pedicellariae confined to base of ray.

BENTHOPECTEN POLYCTENIUS Fisher.

Plate 51, figs. 2, 3; plate 52, fig. 2; plate 55, fig. 4.

Benthopecten polyctenius FISHER, 1913*c*, p. 208.

Diagnosis.—Closely related to *B. violaceus* (Alcock), but differing in having abactinal pedicellariae, inferomarginal pedicellariae far along the ray (in adult specimens), more numerous furrow spines, and 20 instead of 24 adambulacral plates to the first 10 inferomarginals. R=224 mm., r=18 mm., R=12+r; breadth of ray at base, 23 mm. Abactinal area of large specimen with numerous large pedicellariae extending far along ray; abactinal plates with 4 to 8 short spinelets, and scattered spines on disk only; superomarginals with 1 spine, together with 2 unequal accessory spinules and 3 or 4 slender spinelets proximally, and only 1 accessory spinule over most of ray; 2 inferomarginal spines; 2 subambulacral spines, with often a third, smaller accessory; furrow spines 13 or 14 (9 or 10 on first 2 plates); 7 or 8 oral spines and 3 to 5 suboral spines; 20 adambulacral plates correspond to the first 10 inferomarginals, omitting the odd plate.

Description of type.—Abactinal area with only short spinelets on rays and a few scattered spines on disk, the largest on the primary basal plates. Plates of ray with commonly 5 to 8 very short spinelets, which become abruptly longer and thicker on the papular area of disk and base of ray, where there are usually 4 to 6 to a plate. The spinelets are round tipped, slightly roughened, and invested with membrane. The spines of the disk are surrounded by upward of 10 spinelets. Numerous large pedicellariae composed of 2 or 3 combs of about 5 to 7, slightly curved, pointed or blunt spines are scattered over disk and for a variable distance along the median line of ray—usually nearly to the end. The pedicellariae on the disk are 1.75 to 2.25 mm. in diameter.

Papulae distributed all over disk and on the ray as far as the fourth superomarginal, the distal margin of the area being two-lobed.

Superomarginal plates confined to side wall of ray, and much longer than high. Each bears a long, slender, tapering spine, close to the upper margin, 8 or 9 mm. long (equal to about 1⅓ plates in length). The first 4 plates have usually 2 unequal, accessory spines, together with 3 or 4 slender spinelets. Beyond this point there is at first 1 accessory spine, much shorter than the principal spine, and gradually this decreases in size and merges in with the 2 or 3 spinelets which accompany the principal spine. The interradial plate is higher than the rest and bears at the upper end 4 prominent spines, one of which is generally larger than the rest.

Inferomarginals very nearly opposite superomarginals, not alternate as Alcock states is the case with *violaceus*. Inferomarginal spines 2, the lower the shorter. Very conspicuous pedicellariae with 2 semicircular or arcuate combs (containing upward of 10 spines) are present on the transverse suture between nearly all the inferomarginal plates except the last dozen. The general surface of the marginal plates is bare except for a few widely scattered spinelets.

Actinal intermediate areas small, with 8 to 12 large pedicellariae. The plates bear 1 to 3 slender spinules.

Furrow spines 8 or 9 on the first 2 plates, gradually increasing to 13 or 14. They are very slender and bluntly tipped. Subambulacral spines usually 2, commonly 4.5 mm. (or 2.5 plates) long. A third small spine, about as large as a furrow spine, stands at outer end of series and is sometimes enlarged into a regular suboral; another small spine usually stands on the adoral half of the plate, near the above series. Twenty adambulacral plates correspond to the first 10 inferomarginals, omitting the odd plate.

Mouth plates with 7 or 8 marginal spines and 3 to 5 suboral spines, the latter in a series along the middle of the rather narrow exposed surface, with 1 spine between the innermost spine and the inner aboral corner of the plate. The 2 inner spines of the marginal series are enlarged.

Madreporic body convex, prominent, situated its own diameter from the marginal plate; striae fine, irregular. There is a tuft of prominent unequal spines on the adcentral side of the madreporic body.

Variations and young.—The type is a very large specimen. The chief differences in the younger examples are: Fewer abactinal pedicellariae (confined to papular area); usually fewer spinelets on abactinal plates; papulae extending to about the inner end of third superomarginal; less conspicuous accessory superomarginal spines; inferomarginal pedicellariae confined to base of ray (in small specimens) or interrupted and irregular in occurrence on the outer part; fewer furrow spinelets (7 to 9 in a specimen with R=80 mm. and a maximum of 11 in another with R=120 mm.); as few as 2 actinal interradial pedicellariae, or even none in a specimen with R equal to 35 mm.

Type.—Cat. No. 32630, U.S.N.M.

Type-locality.—Station 5654, Gulf of Boni, Celebes, 805 fathoms, bottom not recorded, bottom temperature 38.3° F.; 12 specimens.

Distribution.—Known only from type-locality.

Specimens examined.—Twelve, from type-locality.

Remarks.—The largest specimen differs very markedly from *B. violaceus* (Alcock); but the type of the latter has R about 100 mm., and when comparison is made with an equal-sized example of the present form, the differences are by no means so striking. The type of *B. violaceus* is probably but half grown. A large specimen would very likely have more numerous pedicellariae, more numerous abactinal spinelets, and more numerous furrow spines.

The following are the differences between *B. violaceus* and *B. polyctenius* of equal size:

B. violaceus.	*B. polyctenius.*
24 adambulacral plates correspond to first 10 inferomarginals.	20 adambulacrals correspond to first 10 inferomarginals.
No abactinal pedicellariae.	Abactinal pedicellariae few, on disk only. (In the type, numerous on disk and rays).
Inferomarginal pedicellariae in interbrachial arcs only.	Inferomarginal pedicellariae in interbrachial arcs and far along ray also.
Furrow spines, 7 or 8.	Furrow spines, 9 to 11 (as high as 13 or 14 in type).

B. polyctenius belongs to the genus *Pararchaster*, as defined by Ludwig (1910, p. 462). In his key the species would follow directly after *violaceus*, with the differential characters just cited.

BENTHOPECTEN STYRACIUS Fisher.

Plate 53, fig. 2; plate 55, figs. 3, 3*a*.

Benthopecten styracius Fisher, 1913*c*, p. 208.

Diagnosis.—Similar in general appearance to *B. violaceus*, but with numerous abactinal pedicellariae, and very large odd interradial superomarginal spines; differing from *B. polyctenius* in having only 1 or 2 spinelets to each abactinal plate of the ray, much larger interradial superomarginal spines, no accessory superomarginal spines, fewer inferomarginal pedicellariae (none on outer part of ray), fewer furrow spines. R=105 mm., r=10.5 mm., R=10 r; breadth of ray at base, about 10 mm.; odd interradial superomarginal spine, 17 mm. long.

Description.—Abactinal surface in general resembling that of equal-sized specimens of *B. polyctenius*, but the prominent spines of disk and basal portion of ray (papular area) fewer and smaller.

Spinelets fewer, there being only 1 or 2 to a plate beyond the papular area, and on papular areas (including center of disk where papulae are absent) there are 1, 2, or 3 spinelets to a plate. On the scattered plates which have small spines there are 1 to 3 small spinelets in addition. In *B. polyctenius*, of the same size, the plates of ray have upward of 5 spinelets, and on the disk 2 to 5. On the disk and as far along ray as papulae extend are rather numerous prominent subcircular pectinate pedicellariae composed of 2 or 3 combs having each 3 to 5 acute spinelets.

Papulae extending to distal margin of third superomarginal plate (second in cotype), a little farther than in a comparable specimen of *polyctenius*.

Superomarginal plates in form and posture closely resembling those of *B. polyctenius*, but the accessory spines lacking, there being only a small spinule on the first 2 or 3 plates. The odd plate bears a relatively immense sharp spine (14 to 17 mm. long), as long or longer than diameter of disk, and the most characteristic feature of this species. This spine is about 7 mm. long in a comparable specimen of *B. polyctenius*.

The inferomarginals bear 2 spines, the lower one-half to three-fourths the length of the upper, similar to those of *B. polyctenius*. The plates of outer third of ray are very slender and bear, as a rule, only 1 spine. Between the plates of proximal half of ray is a pectinate pedicellaria, but these may be absent from a number of plates, their occurrence being subject to variation.

Actinal interradial areas small, bearing each 2 large pectinate pedicellariae (one interradius has 2.5 pedicellariae).

Furrow spines 7 or 8, slender, bluntly pointed, the successive combs spaced a little less than their base line. (In *B. polyctenius* a comparable specimen has 9 to 11 spines, the combs spaced only one-half the length of their base line.) Subambulacral spines 2, the outer slightly the shorter, with a third quite small spinule usually present adorad of the outer spine. Nineteen to 22 plates correspond to first 10 inferomarginals, omitting the odd plate.

Oral spines 6; suboral, 3, in a series along middle of plate. The armature resembles that of *B. polyctenius*, which may have a few more spines, but the number of spines is variable.

Madreporic body slightly spaced from the odd superomarginal, convex, with radiating striae.

Type.—Cat. No. 32631, U.S.N.M.

Type-locality.—Station 5668, Macassar Strait (lat. 2° 28′ 15″ S.; long. 118° 49′ E.), 901 fathoms, gray mud, bottom temperature 38.2° F.; 2 specimens.

Distribution.—Known only from the type-locality.

Remarks.—Although this species is close to both *B. violaceus* and *B. polyctenius*, its characters seem to warrant its separation. It differs from *B. violaceus* in having numerous abactinal pedicellariae, larger interradial superomarginal spines, no accessory superomarginal spines, rather fewer abactinal spinelets, and fewer adambulacral plates to the first 10 inferomarginals. That *styracius* is a race of *violaceus* is quite within the range of possibility.

As the foregoing description is largely in the form of a comparison between *polyctenius* and *styracius* nothing further need be added.

Family RADIASTERIDAE Fisher.

Mimasterinae SLADEN, 1889, p. 331.—FISHER, 1911*d*, p. 161.
Mimasteridae VERRILL, 1914*a*, p. 282.
Radiasteridae FISHER, 1916*a*, p. 4.

Diagnosis.—Phanerozonia, with small, subequal, subpaxilliform marginals, resembling the Astropectinidae abactinally and the Ganeriidae actinally, but with sucking disks on the tube feet and complete membranous interbrachial septa, and superambulacral plates; abactinal skeleton consisting of penicillate, usually independent, paxillae; actinal plates imbricated in transverse series, tabulate, with a coordinated tuft of spinelets; adambulacral armature a coordinated tuft of spinelets increasing in length toward the two or three almost undifferentiated furrow spinelets; first adambulacral somewhat compressed; mouth plates rather astropectinoid, with a straight or angular marginal series of spines, with or without an unpaired median spine at the inner angle.

Remarks.—In respect to its systematic position *Mimaster* Sladen has been a rather restless genus. Sladen recognized its curious combination of apparently incompatible characters and made it the type of a subfamily of the Pentagonasteridae. It has been variously regarded as belonging to the Archasteridae (Perrier, 1894), Plutonasteridae (Verrill, 1899), and Goniasteridae (Fisher, 1911*d*), until recently it was dignified by being raised to family rank (Verrill, 1914). Professor Verrill's disposition seems to be the best way out of the difficulty.

Since the publication of the Asteroidea of the North Pacific, I have had the opportunity of examining two true Mimasters, *M. tizardi* Sladen, and *M. notabilis* Fisher, as well as the *M. cognatus* of Sladen, which appears to be generically distinct.

The abactinal skeleton of *Mimaster* is strongly astropectinoid, the plates being typical penicillate paxillae, but the marginals, while perhaps neutral, remind one strongly of the marginals of *Cycethra*, a resemblance heightened by the actinal and adambulacral armature, which is decidedly ganeriid. By having definite sucking disks on the tube feet *Mimaster* is removed from proximity to *Leptychaster*, an association suggested by the dorsal surface, including the marginals, while it can not be placed in the Ganeriidae because it possesses superambulacral plates and lacks the heavily calcified internal interbrachial pillar, the reticulated, imbricated, abactinal skeleton, and the asterinoid abactinal armature of *Cycethra* and *Ganeria*.

In *Mimaster* the *membranous* interradial septum forms a complete partition from the side wall of the disk to a free margin close against the stomach; but in *Cycethra* and in *Ganeria* (as in *Solaster* and in *Asterina*) there is a rigid pillar running from above the mouth plates to the abactinal surface, the coelom being undivided between this pillar and the margin (an incomplete calcified septum).

In this connection I would like to call attention to the resemblance between *Ganeria* and the Solasteridae. The marginal plates of *Ganeria falklandica* are essentially like those of Solaster, and in the adambulacral armature we find a very generalized form of the peculiar pectinate type of the Solasteridae. The form and armature of the mouth plates, the actinal intermediate plates, and even the adambulacral plates can, however, be more nearly matched in the Asterinidae. The abactinal skeleton, though of an open reticulate form, especially on the disk, is more nearly like that of the Asterinidae than like that of the Solasteridae.

While perhaps in some way related to the Ganeriidae, I think *Mimaster* is well within the Phanerozonia. *Gephyreaster*, which I formerly associated with it in the Mimasterinae, and *Priamaster* Koehler seem to belong in this family in a special subfamily, the Priamasterinae.[1] The internal anatomy of *Priamaster* has not been described.

The purely nomenclatorial side of the matter is complicated by *Radiaster elegans* Perrier. Through the kindness of Dr. H. L. Clark I have examined the type (unfortunately dried) in the Museum of Comparative Zoölogy (No. 909, Dominica, West Indies, 982 fathoms). From every outward indication this species is a typical *Mimaster*. *Radiaster* has one year priority.

Subfamily RADIASTERINAE Fisher.

SYNOPSIS OF THE GENERA OF RADIASTERINAE.

*a*¹. Gonads confined to the disk and consisting of several tufts springing from a common point close to the interbrachial septum; hepatic coeca with long subdivisions, so that each ray appears to have from six to ten separate coeca of unequal length; tube feet with well-developed sucking disks; lateral abactinal plates not cruciform nor regularly imbricated.
Radiaster[2] Perrier.

---

[1] Fisher, 1917*d*, p. 172.

[2] Component species: *Radiaster elegans* Perrier, genotype; *R. tizardi* (Sladen); *R. notabilis* (Fisher).

a^2. Gonads consisting of numerous tufts extending in a radial series near the superomarginal plates for over half the length of the ray; hepatic coeca two, not appearing multiple on account of long subdivisions as in the preceding; tube feet with very small sucking disks; lateral abactinal plates distinctly four-lobed, regularly imbricated____*Mimastrella*[1] Fisher.

Genus RADIASTER Perrier.

Radiaster PERRIER, 1881, p. 17. Type, *R. elegans* Perrier.—FISHER, 1916*a*, p. 4.

Mimaster SLADEN, Proc. Royal Soc. Edinburgh, vol. 11, 1882, p. 702. Type, *M. tizardi* Sladen; 1883*b*, p. 579, pl. 34; 1889, p. 331.

RADIASTER NOTABILIS (Fisher).

Plate 41, figs. 6, 6*a*; plate 57, fig. 2; plate 58, fig. 1.

Mimaster notabilis FISHER, 1913*a*, p. 624.
Radiaster notabilis FISHER 1916*a*, p. 5.

Diagnosis.—Differing from *R. tizardi* (Sladen) in having much slenderer rays, more numerous paxillar spinelets, more prominent paxilliform marginal plates, a narrower actinal intermediate area on ray, and fewer adambulacral spinelets. R=104 mm., r=35 mm., R=3 r: breadth of ray at base, 39 mm. Paxillae spaced with upward of 75 delicate, terete, pointed spinelets, either closely appressed in a cylindrical upright group or radiating and forming a subglobose crown; marginal plates small, paxilliform, the inferomarginals the larger, about as high as the length of the base, and standing out horizontally from ambitus; the crown of spinelets compressed, wider than long; actinal intermediate plates in 10 or 11 very regular chevrons and extending to the end of the ray; halfway along ray about 5 actinal intermediate plates in a transverse series (8 or 9 in *tizardi*); intermediate plates with spaced, cylindrical, upright paxilliform groups of slender spines; adambulacral armature resembling that of *M. tizardi*, but with 13 or 14 (instead of 15 to 20) spinelets, 2 or 3 of which (about 1.5 plates in length and considerably stouter than the rest) occupy the furrow margin.

Description.—Paxillae spaced; spinelets numerous, very delicate, terete, pointed, forming sometimes a cylindrical flat-topped group and sometimes from their radiating position a more or less hemispherical group. The abactinal surface very greatly resembles that of a *Dipsacaster*. The paxillae are arranged at the sides of the area in a sort of quincunx—in series oblique to the radial line, but in series trending both distad and proximad from any given point. The paxillae are a little smaller on the center of disk than toward the margin, where the longest are found, but the difference is not great. One of the larger paxillae has between 50 and 75 very delicate, sharp, practically capillary spinelets, slightly shorter to slightly longer than the stout cylindrical convex pedicel. On the outer part of the ray the pedicel is usually shorter than the spinelets. The madreporic body is covered by about 20 very large paxillae, which stand on its surface and about the edge. The spinelets are delicate and very numerous and when the crown is expanded it is 2 or even 3 times as broad as that of an ordinary paxilla. The papulae are numerous and distributed all over the abactinal area.

---

[1] Fisher, 1916*a*, p. 5; genotype, *Mimaster cognatus* Sladen.

The bases of the paxillae are very irregularly lobed and are separated one-fourth to one-half their diameter. On the margin of the area the plates are sometimes subquadrate in general form, but elsewhere the plates are roundish with 5 or 6 short lobes or are quite irregular.

Marginal plates small, paxilliform, both series confined to the ambitus; margin of ray thin, formed by the united bases of the marginal paxillae. Superomarginal paxillae, 52 or 53, proximally with the crown wider than long, distally with the crown cylindrical. The spinelets are a little longer than the pedicel. Each superomarginal stands directly above and close to the corresponding inferomarginal which is half again as large, and consecutive pedicels are separated by 1 or 2 times their diameter. The inferomarginal paxillae are wider than long at the crown and are about as high proximally as the distance between the middle of one crown to the middle of the next. These paxillae greatly resemble the marginal paxillae of *Solaster*. The inferomarginals define the ambitus while the superomarginals are dorsal in position. Terminal plate subcircular, with a shallow notch on the side toward paxillar area. It is covered with short spinelets.

Actinal interradial areas large, but narrower on ray than in *R. tizardi*. A single series of plates reaches the end of ray. The plates are arranged in very regular series, corresponding to the adambulacral plates, and extending to the marginals but not corresponding to them. The first 10 inferomarginals correspond to about 14 series of intermediate plates. The intermediate plates also form regular longitudinal series or chevrons. The first chevron has paired interradial plates behind the mouth plates, but most of the other chevrons have an unpaired plate at the apex, interradially, though sometimes out of place slightly. There are 10 or 11 of these chevrons, the outermost very small. Halfway along the ray in *R. tizardi* there are 8 or 9 plates in a transverse series; in *R. notabilis* only 5; three-fourths the length of ray, in *tizardi*, 5 or 6 plates in a transverse series, and in *notabilis*, only 2 or 3. Each plate bears on a low eminence a cylindrical, paxilliform, penicillate group of 20 to 25 slender, sharp, closely coordinated spinelets, the peripheral about half as long as the central. The groups are spaced 1 to 2 times their diameter. The spines are much longer than the low tabulum. The appearance is very similar to that of *R. tizardi*, there being shallow channels between consecutive transverse rows. From the coelomic side the plates are seen to imbricate strongly in the transverse series and slightly in respect to the plates on either side.

Adambulacral spines 13 or 14, slender and pointed, in an upright coordinated group and decreasing very rapidly in length from the 2 or 3 on the furrow margin (equal to 1½ plates in length) to the 3 or 4 small spinelets on outer edge of the group. In some groups an arrangement in 4 longitudinal series is evident. The shape of the groups is subcircular or roughly three-sided, and they are spaced from one another about half the length of the plate. The tips of the marginal spines are slightly compressed.

Mouth plates narrow, densely covered with slender, tapering, bluntly pointed, upright spines, which form a coordinated group for each pair of plates. The outer margin of each plate has only a slight angle between the furrow margin and that adjacent to the first adambulacral. The marginal spines proper are 6 or 7, slender, slightly flattened, bluntly pointed, the innermost the stoutest; 10 to 12 smaller spinelets continue this series to the outer end of the plate. Another series of similar spinelets follows the margin of the suture from the outer to inner end of plate, and an intermediate series is present on the outer part of the plate. There are, in all, between 50 and 60 spines to each plate.

Madreporic body large, with an irregular outline, and entirely obscured by relatively very large paxillae. It is situated with the inner edge about midway between center and margin.

Gonads in a single tuft on either side of each membraneous interbrachial septum. Superambulacral ossicles, broadly elliptical in form, are present.

Young.—The young specimen from station 5605 has R 10 mm., r 5.5 mm. The spinelets are extraordinarily delicate. The chief difference between this specimen and the adult lies in the fewer and relatively longer spines and the much lower tabulum of the marginal plates. The rays are, of course, relatively shorter and broader. The paxillae have ordinarily 10 to 25 spinelets longer than the tabulum. The spinelets of the marginal plates are very delicate and in spaced groups on the middle of the convex plates. The proximal inferomarginals have a low tabulum, scarcely half as long as the spines, which are as long or longer than their plate. The terminal plate is prominent and closely covered with delicate spinelets. Actinal intermediate plates in 3 chevrons; the spinelets long, delicate, in spaced groups. Adambulacral groups of spinelets relatively a little closer than in the adult. The spinelets are so delicate and relatively so much more prominent than in the adult that this small specimen might aptly be described as shaggy.

Type.—Cat. No. 30533, U.S.N.M.

Type-locality.—Station 5630, vicinity of Batjan Island (south of Patiente Strait), Molucca Islands (lat. 0° 56′ 30″ S.; long. 128° 05′ E.), 569 fathoms, coral sand, mud; 1 specimen.

Distribution.—Molucca Islands and Gulf of Tomini, Celebes.

Specimens examined.—Two; besides the type an immature specimen from station 5605, Gulf of Tomini, Celebes, 647 fathoms.

Remarks.—It is somewhat startling to find such a near relative of the North Atlantic *R. tizardi* in the Moluccas. So far the genus has not been found in the North Pacific, although it most likely occurs there.

As noted in the synopsis of the genera of this family, the *Mimaster cognatus* of Sladen is not congeneric with *tizardi*, but is separated by important anatomical features which justify the erection of a separate genus.

Family GONIASTERIDAE[1] Forbes, 1841 (emended).

Subfamily PSEUDARCHASTERINAE Sladen, 1889, extended.

Genus PSEUDARCHASTER Sladen.

Pseudarchaster SLADEN, 1889, p. 109. Type, *Ps. discus* Sladen.

PSEUDARCHASTER JORDANI Fisher.

Pseudarchaster jordani FISHER, 1906, p. 1038, pl. 10, figs. 7, 7*a*; pl. 19, figs. 2, 2*a*.

Astrogonium jordani KOEHLER, 1909, p. 49.

Specimens examined.—Five, from the following stations:

Station 5582, vicinity of Darvel Bay, Borneo, 890 fathoms, gray mud, fine sand, bottom temperature 38.3° F.; 2 specimens.

Station 5586, Sibuko Bay, Borneo, 476 fathoms, gray mud, bottom temperature 41.1° F.

Station 5587, Sibuko Bay, Borneo, 415 fathoms, green mud, sand, coral, bottom temperature 42.3° F.

Station 5618, Molucca Passage, 417 fathoms, gray mud.

Type-locality.—Station 3474, south coast of Oahu Island, Hawaiian Islands, 375 fathoms, fine white sand.

Distribution.—Hawaii to the Molucca Islands, Borneo, and the Indian Ocean, off southern India, 375 to 1,085 fathoms.

Remarks.—The specimens listed above differ from typical *jordani* in a few minor details. All but the example from station 5618 are larger than the type, that from station 5586 having R=141 mm., r=41 mm. The specimen from station 5587, which is nearest *jordani* in general appearance, has a relatively smaller disk than the large specimen, and another, with R=78 mm., from station 5582.

---

[1] For a discussion of this family and a key to the genera, see Fisher, 1911*d*, pp. 158–174; Verrill, 1914*a*, pp. 285–289, gives valuable critical notes.

A comparison of the specimens with Koehler's description of *Ps. mozaicus* (1909, p. 50, pl. 1, fig. 3) indicates that the principal differences are the presence of superomarginal spines in *mozaicus*, fewer central granules on the abactinal plates, fewer transverse series of superomarginal granules, and fewer subambulacral spinelets. However, the large specimen has 4 to 6 short, sharp, lateral spines on each of the plates of the interbrachium, these becoming reduced to 2 or 3 on the outer part of the ray. None of the others show a sign of the spines, yet they appear to belong to the same species.

Koehler writes that all of his 15 specimens of *Ps. mozaicus* had superomarginal spines. Moreover, he states that as the external border of the plate is approached, the granules elongate and become conical spinelets, among which 1, 2, or even 3 are conspicuous by being longer than the others. In the large specimen, above mentioned, the granules do not gradually become longer, but there is an abrupt transition at the angle between the dorsal and very low lateral face of the plate. In Koehler's figure the spines are plainly shown as being spaced on the outer third or even half of the plate. In his observations on the Indian specimens of *jordani* Koehler states that on the edge of the plates [outer edge, as I understand it] the granules are somewhat elongated and occasionally form small pointed cones. His largest specimen had R=64 to 70 mm.; perhaps there is a tendency in the old specimens of this species to acquire lateral spines.

The following differences seems to separate the Borneo and Molucca specimens of *jordani* from *Ps. mozaicus* as described and figured by Koehler. In *mozaicus* the larger abactinal plates have 5, 6, or 7 central well-spaced granules, in addition to 20 to 26 slenderer peripheral ones; in *jordani* there are 8 to 15 central granules on the larger plates, and upward of 20 in the largest specimen. Koehler states that the granules of the superomarginals form about 5 transverse series; in *jordani* I find 7 or 8, and the series are not at all regular. In *mozaicus* the furrow spines are generally 5; in *jordani* 6 or 7. Koehler describes the subambulacral spines as forming 2 series close together and a little irregular, with 2 to 4 spines in each; 1 or 2 in the first series is much longer than the others. This would indicate that the total number of spines does not exceed 8; 12 to 20 is the usual number in *jordani*, although in small specimens it is less, and they do not form series. Three to 5 enlarged subambulacral spines stand on the proximal, and 2 or 3 on the distal plates of the large specimen of *jordani*: the other specimens have 2 or 3 enlarged spines proximally and 1 to 3 distally.

All the specimens but those from station 5582 have a variable number of post-adambulacral fasciolar pedicellariae or pectinate fascioles. These were not well pronounced in the type.

In conclusion it may be stated that the relationship of *Ps. mozaicus* to *Ps. jordani* is not at all clear. If the specimens collected by the *Albatross* are really all of one species they indicate that the two forms approach much closer than heretofore supposed.

PSEUDARCHASTER OLIGOPORUS Fisher.

Plate 59, fig. 1; plate 60, fig. 3; plate 91, figs. 2, 2*a*.

Pseudarchaster oligoporus FISHER, 1913*a*, p. 625.

Diagnosis.—Most nearly resembling *Ps. pectinifer* Ludwig and *Ps. dissonus* Fisher. R=87 mm., r=21 mm., R=4.1 r; breadth of ray at base, 24 mm.; rays slender, long, and very attenuate at the extremity; side of ray low, rounded; marginal plates small, especially distally, where the superomarginals are confined to side wall of ray and are longer than wide, square, or slightly wider than long; papular area restricted to center of disk, and petaloid radial areas extending about one-fourth the length of ray; abactinal plates tabulate on papular area, the roundish tabula low, spaced, and bearing 20 to 30 polygonal granules; outside of papular area plates elliptical or oblong, arranged in oblique transverse series and with very low tabulum, or distally none; superomarginal plates with coarse, spaced, covered granules; inferomarginals with pointed, conical, appressed spinelets, and proximally 8 to 12 appressed sharp spines in a zigzag transverse series, these becoming reduced to 1 or 2 toward the extremity of ray; actinal intermediate plates in 5 chevrons, the series adjacent to adambulacrals extending to tenth or eleventh inferomarginal, each plate armed with 1 to 3 tapering, sharp spines, and 5 to 20 short, sharp, spaced peripheral spinelets; a variable number of plates adjacent to adambulacrals with the transverse sutures armed with fasciolate pectinate pedicellariae, the spinelets being short and broad tipped; furrow series angular with 8 or 9 short, sometimes slightly compressed, blunt, or bluntly pointed spines, and 1 or 2 tapering, pointed subambulacral spines, surrounded by 5 to 10 shorter, spaced, pointed spinelets.

Description.—Abactinal plates medium-sized, not at all compactly placed, but distinctly spaced. The papular area is relatively small, being confined to the center of disk and 5 petaloid radial areas extending two-fifths R, or one-fourth the length of ray. Here the plates are tabulate, the paxillar crowns being roundish and spaced, and arranged in longitudinal and oblique transverse series, the plates decreasing regularly in size from the central area of disk toward the margin and toward the end of the ray. Outside the papular areas the plates have scarcely any tabulum and the crown of granules is elliptical, oblong, or irregular, and arranged in oblique transverse series. On the papular area the longitudinal series of plates are perfectly distinct, but outside this area can not be easily traced. An average large paxilla of the radial series has between 20 and 30 polygonal granules, some, but not all, on the periphery being in the form of short spinelets.

The shape of the abactinal plates varies. On the papular area they are subcircular or broadly elliptical, sometimes with very slight peripheral indentations. The low plates of the oblique transverse series outside the papular areas are irregularly oblong, with angular or rounded extremities. In the midradial region beyond the papular areas the plates are oval, elliptical, or various irregular combinations of these forms.

Superomarginals, 56 in number, form a steep, arched bevel interbrachially, and beyond the proximal fourth of ray are confined to the lateral wall, very nearly the entire width of the ray being occupied by the area of abactinal plates. The first 8 or 9 plates are wider than long, the width gradually decreasing from the first plate to the tip of the ray, so that at the middle of the ray the superomarginals are only one-half as wide as at the interradial line. From the tenth to twenty-fifth or twenty-eighth plates the length equals or slightly exceeds the width, while on the last fourth the width is again slightly greater than the length. The plates are covered with slightly spaced, circular, convex granules, considerably coarser than those of the abactinal plates, and a row of much slenderer ones surrounds the plate. The grooves between the plates are shallow, but well marked. Terminal plate granular, longer than wide, slightly saddle-shaped, with 3 terminal spines.

Inferomarginals small, corresponding to the superomarginals, and decreasing in width regularly toward extremity of ray. They are a trifle wider than the superomarginals on the middle of the ray, but about the same width proximally and distally, and on the outer half of ray are very small for this genus, being only a little larger than the adambulacrals. The side of the ray is rather thin and rounded, and proximally more than half of the height is occupied by the superomarginals, but distally each series occupies about half. The plates are covered with spaced, pointed, conical, or thickly fusiform spinelets, the median area being occupied by a transverse zigzag series of tapering, sharp, appressed spinules, 8 to 12, proximally, becoming reduced to 1 or 2 on the small distal plates. These spines sometimes are most numerous near the outer end of the plate, and sometimes form 2 irregular transverse series.

Actinal intermediate plates in 5 chevrons and an odd plate adjacent to margin, the plates nearest the furrow being the largest and extending to tenth or eleventh inferomarginal, while the second series extends to the seventh or eighth. The plates are armed with 1 to 3 tapering, sharp spines about as long as the width of the plate, the periphery being occupied by short, sharp, spaced spinelets. On the transverse margins of the first series of plates the spinelets are stouter and round-tipped and form, with their companions of the adjacent plate, a pectinate pedicellaria over the suture. These fasciolate pedicellariae are not constant. In the type they extend about half the length of the first series, but in the cotype from the same station they are confined to the first few plates. The proximal pedicellariae have 6 or 7 spines in each comb.

Adambulacral plates longer than wide, with a very angular furrow margin bearing 8 or 9 subequal, rather short, compressed, blunt spines. On the outer part of the ray those on the angle of the apophysis separate consecutive pairs of tube feet, while the lateral numbers have their broader side to the furrow and act presumably as protectors of the underlying feet. There are 1 or 2 tapering, pointed, subambulacral spines, proximally about as long as the furrow spines, distally longer, partly surrounded by 5 to 10 shorter, bluntly pointed, spaced spinelets, which stand on the margin of the plate, with occasionally 1 or 2 between the subambulacral and the apex of the furrow angle.

Mouth plates convex actinally, with a broad median suture. Furrow spines, 8 or 9, stout, blunt, very similar to the corresponding adambulacral spines, the inner 2 or 3 being compressed and slightly longer than the others. The unpaired median mouth spine is compressed, heavy and blunt, and largest of all. A series of 9 or 10 stout, rather short, pointed spines follows the median suture margin and another series of 4 or 5, close to them, continues the furrow series along the lateral suture margin.

Madreporic body small, convex, with coarse ridges, and situated a little nearer center than margin.

Superambulacral plates present. Gonads in a single tuft on either side of the interbrachial septum.

Type.—Cat. No. 30534, U.S.N.M.

Type-locality.—Station 5609, Gulf of Tomini, Celebes (lat. 0° 11′ S.; long. 121° 16′ E.), 1,092 fathoms, green mud; bottom temperature 36.3° F.; 2 specimens.

Distribution.—Known only from the Gulf of Tomini, Celebes, 1,089 to 1,092 fathoms; bottom temperature 36.3° F.

Specimens examined.—Three; besides the types, 1 from station 5608, Gulf of Tomini, 1,089 fathoms, gray mud, bottom temperature 36.3° F.

Remarks.—This abyssal species has the general form of *Ps. pectinifer* Ludwig and *Ps. dissonus* Fisher, from the east and north Pacific. It differs in having longer and slenderer rays, the distal portion being especially attenuate; smaller marginal plates; a very restricted papular area; smaller and distinctly spaced tabulate plates on the paxillar area, the others being low and not tabulate, and shorter furrow spines. In *Ps. dissonus* the abactinal plates are very compact and the marginal plates are covered with thickened papilliform spinelets so closely placed that the outlines of the plates are difficult to discern. The postadambulacral fasciolar pedicellariae are valvate or valvate-pectinate, some of them resembling the bivalved pedicellariae of the Goniasterinae and Hippasterinae. They are of a very peculiar form, not to be confused with the regular spiniform pectinate pedicellariae of *oligoporus*. In *dissonus* the proximal adambulacral plates are widely spaced so that the intermediate plates sometimes come to lie near or on the furrow; and in *dissonus* the furrow spines are considerably longer than in *oligoporus*. Over a considerable portion of the ray of *oligoporus* the abactinal plates are low and without distinct tabulum. The small papular area is a very characteristic feature of this species.

The attenuate, long rays and small marginals will readily separate *oligoporus* from *tessellatus*, *mozaicus*, *jordani*, and *myobrachius*. *Pseudarchaster roseus* (Alcock) from the Laccadive Sea, 740 fathoms, is a long-rayed form, R equaling 4 r. Koehler (1909, p. 50) writes that in the type there are no inferomarginal spines—merely granules—and Alcock describes the adambulacral plates as having actinally 3 unequal longitudinal series of close prismatic granules. Presumably there are no enlarged subambulacral spines. This species was described as a *Mediaster*. Koehler states that it is a *Pseudarchaster*. From the description it would appear to bear considerable resemblance to the new *Aphroditaster* herein described. It is certainly very different from *Ps. oligoporus*, which has armed inferomarginals and prominent subambulacral spines.

Genus APHRODITASTER Sladen.

Aphroditaster Sladen, 1889, p. 116. Type, *A. gracilis* Sladen.

APHRODITASTER MICROCERAMUS Fisher.

Plate 59, fig. 2; plate 60, fig. 1; plate 70, fig. 5; plate 91, fig. 1.

Aphroditaster microceramus Fisher, 1913*a*, p. 626.

Diagnosis.—R=46 mm., r=13.5 mm., R=3.4 r; breadth of ray at midinterbrachium, 15 mm. Disk fairly large, with open, rounded interbrachia; rays slender and pointed; all plates covered with a close tessellation of flat-topped or slightly convex polygonal granules; no spines except on adambulacral and mouth plates: abactinal area narrower on rays than width of broad, arched superomarginals; abactinal plates compactly placed with usually 6 to 8, but sometimes as many as 12, polygonal crowded granules, or on outer part of ray 3 or 4: marginals much broader than long, forming a smooth, evenly rounded margin to ray; actinal intermediate plates restricted to disk and evenly granular: furrow margin slightly convex proximally, decidedly convex distally with 7 to 9 short, stubby spinelets and 12 to 14 compact, polygonal subambulacral granules in 3 or 4 longitudinal series; no specialized subambulacral spines; no pedicellariae; adambulacral armature resembling that of *Ceramaster.*

Description.—Area of abactinal plates narrower on ray than width of superomarginal plates as seen from above; this narrow band diminishes in width toward the end of ray very gradually, the abactinal plates reaching the terminal plate. Opposite the fourth superomarginal there are 7 longitudinal series of abactinal plates, counting across the ray; opposite the eighth, 5, and opposite the twelfth, 3. This point is about the middle of the ray; the 3 longitudinal series continue to the end, the plates becoming smaller and more closely fitted together. Abactinal plates low tabulate, the tabula being elliptical in cross-section and very much narrower than the crown of the few relatively large polygonal, compactly placed granules. These granules are about as high as broad and wider at the top than base. A large radial paxilla has upward of 12, but usually there are only 6 to 8, with 1 or none occupying the center; on the outer part of ray there are generally 3 or 4, occasionally only 1 or 2. The usual form for the paxilla crown is hexagonal, but they are not always symmetrical; the largest are on the radial areas. The papulae extend only to the fourth superomarginal, and are distributed all over the disk.

The plates of the papular areas are nearly circular in general outline, with 6 short blunt lobes by which they are in contact, or slightly overlap. Outside the papular areas the carinal plates are circular or hexagonal, while the laterals are longer than broad, elliptical in shape, somewhat like half a hexagon.

Superomarginals, 37 in number, are wide and short, encroach conspicuously upon abactinal area, and form an arched border thereto; the lateral face is lower than the width of the dorsal, and passes very gradually into it. Plates covered with a close mail of mostly hexagonal granules, about the size of those of abactinal plates, in 5 or 6 not clearly defined transverse series, proximally, becoming reduced distally to 4, 3, and 2. The surface of the plates is smooth and the granules of neighboring plates are fitted so tightly together that no channel is perceptible. Terminal plate, elongate, elliptical, covered with closely placed granules.

Inferomarginals much wider than long, and corresponding to the superomarginals, covered with similar granules, a little smaller and more numerous actinally. No specialized spines.

Actinal intermediate areas small, the plates in series extending from adambulacrals to the inferomarginals, and less regularly in series parallel to the furrow; that adjacent to the adambulacrals ending opposite the suture between the third and fourth inferomarginal; the next series ending between the second and third. There are 5 chevrons altogether, with the beginning of a sixth, but no odd interradial plates in any of the chevrons. Plates with a uniform covering of granules similar to those of the inferomarginals, but not quite so close together.

Adambulacral plates about as wide as long, except the first 2 or 3, which are wider than long. Furrow margin only slightly convex proximally, gradually becoming decidedly convex on the outer half of the ray. Furrow spines, 7 to 9, usually 8, about half as long as width of plate, subequal, compressed, blunt, the laterals the heavier, and with the side to furrow; the central spines are 4-sided in section, the narrow sides exposed. Subambulacral granules polygonal, in 3 or 4 longitudinal series, the granules increasing in length slightly toward the furrow, and with flat or convex tips. There are 12 to 14 subambulacral granules and they are very similar in form to the adjacent actinal intermediate or inferomarginal granules. No enlarged or specialized subambulacral spines are present, but the last dozen plates have the last or next to the last of the 5 or 6 furrow spinelets enlarged into a short clavate spinule, following a tendency which is usually exhibited by the subambulacral spines or granules of the Goniasteridae—namely, of having an enlarged subambulacral spine on the outer part of the ray even if none are present proximally.

Mouth plates narrow, with a pointed, clavate, robust, median, unpaired tooth, and on either side 2 successively shorter spines. Following these, facing the furrow rather than the actinostome, is an independent series of 5 slender, slightly flattened, subtruncate spines, increasing in length and appressed against the suboral spines. A series of 8 or 9 of the latter follow the median suture margin, the outer 4 or 5 granuliform, while the furrow series is continued along the lateral suture by 4 or 5 granules, 2 or 3 slender spinules forming an intermediate series at the middle of the plate.

Type.—Cat. No. 30535, U.S.N.M.

Type-locality.—Station 5648, Buton Strait, Celebes (lat. 5° 35′ S.; long. 122° 20′ E.), 559 fathoms, green mud, bottom temperature 39.2°; 1 specimen.

Remarks.—This species differs from *Aphroditaster gracilis* Sladen (Azores, 1,000 fathoms), in having larger, fewer, and more compact abactinal granules, polygonal in form; shorter marginal plates armed with flattish, polygonal, compact granules (spinelets on inferomarginals of *gracilis*); compact, polygonal, actinal intermediate, and subambulacral granules, rather than spinelets; and in lacking the postadambulacral fascioles.

The "postadambulacral fascioles" are identical with those of *Pseudarchaster* and are now known to be incipient pedicellariae. In *Pseudarchaster* they are in some species constantly present, while in others they are not; not all species have them. In *Aphroditaster* the fasciolar pedicellariae are not of generic importance, as shown by their presence in *A. gracilis* and their absence in the present species.

Aphroditaster agrees with *Pseudarchaster* in general appearance and in having an odd tooth at the inner end of the combined mouth plates. It differs in having a straight or only slightly curved furrow margin to the adambulacral plates, an even comb of furrow spines, and no specialized or enlarged subambulacral spine or spines. The two genera are very close, and I doubt if the young of some species of *Pseudarchaster* could be distinguished generically from young *Aphroditaster*.

Genus PARAGONASTER Sladen.

Paragonaster SLADEN, 1889, p. 310. Type, *P. ctenipes* Sladen.

KEY TO THE SPECIES AND SUBSPECIES OF PARAGONASTER HEREIN DESCRIBED.

a^1. Proximal plates of the single series which separates the superomarginals wider than long, and conspicuously wider than the adjacent radial plates of disk; peripheral granules of the plates of papular area smaller than the central granules; the two sorts subequal elsewhere; central granules slightly spaced, not compact; numerous inferomarginal and actinal intermediate spines; fasciolate pedicellariae between nearly all the adambulacral plates..*hypacanthus*, p. 228.

a^2. Proximal plates of the radial series of ray narrower than long and narrower than the adjacent radial plates of disk; peripheral granules of all the abactinal plates smaller than the central, which are very compactly placed; very few inferomarginal and no actinal intermediate spines; incipient fasciolate pedicellariae between the first few adambulacral plates only, rudimentary distally..................*stenostichus*, p. 232.

PARAGONASTER CTENIPES HYPACANTHUS, Fisher.

Plate 70, fig. 3; plate 71, fig. 2; plate 72, fig. 1; plate 91, figs. 9, 9*a*.

Paragonaster ctenipes hypacanthus FISHER, 1913*a*, p. 627.

Diagnosis.—Closely resembling *P. ctenipes* Sladen, but differing in having more numerous granules on the abactinal plates, more numerous and conspicuous inferomarginal spinules and smaller and more distantly spaced inferomarginal granules, a prominent central spine on many of the actinal intermediate plates, and proximally 2 enlarged subambulacral spines. R=88 mm., r=19 mm., R=4.6 r;

breadth of ray at midinterbrachium, 22 mm.; at inner limit of the single row of abactinal plates (distal margin of fourth superomarginal plate) 12.5 mm., or length of first 6.3 superomarginals measured on ambitus (varies to 5); general form as in *ctenipes*, but rays a little slenderer; abactinal plates with 15 to 25 central and 25 to 30 peripheral granules, which are slenderer on the papular areas; distal carinal plates of disk with upward of 40 central and 35 to 45 peripheral granules; inferomarginal plates with proximally 6 to 10 appressed sharp spinules, reduced to 3 or 4 at middle of ray, then 2, a single spinule persisting to near end of ray; furrow spines 7 or 8, continued along the transverse margins as smaller interlocking spinelets; subambulacral spines prominent, slender, tapering, sharp, proximally 2, distally 1; in small specimens 1 throughout.

Description.—*P. ctenipes* was described from a comparatively small specimen (R 48 mm.). A comparison of an equal-sized example of *hypacanthus* with Sladen's figure of *P. ctenipes* (1889, pl. 51, figs. 5 and 6) shows that the latter is of stouter build with slightly broader superomarginal plates, especially interbrachially. The abactinal area circumscribed by the marginal plates is arcuate pentagonal, the amount of indentation being variable, but slight. Abactinal plates with more numerous granules than in *ctenipes*. A median radial plate about halfway from the primary radial to base of ray has about 25 to 30 peripheral and 15 to 25 central granules, much the same shape as in *ctenipes*, but on the radial papular area the marginal granules are much slenderer than the central. On the center of disk and a narrow interradial area the marginal granules are as in Sladen's figure (pl. 53, fig. 1). The number of granules increases from the primary radial to the rectangular plates separating the superomarginals and then gradually decreases along the ray. The 2 or 3 plates preceding the rectangular carinals have 35 to 45 rather slender peripheral granules and upward of 40 larger round, truncate, spaced ones. In medium-sized and relatively small specimens the number is not greatly reduced. A specimen from station 5120, about the size of Sladen's type of *ctenipes*, has 23 central and 28 peripheral granules on a primary radial plate. The lateral plates decrease gradually in size toward the margin, and those of the center of disk are a trifle smaller than the radial plates. All the abactinal plates are distinctly tabulate, although the tabulum is low.

Papulae absent from the ray, center of disk, and a narrow interradial band; present, in sixes about each plate, forming a broadly oval radial area, reaching nearly to interbrachial septum. Plates of papular areas with 6 short lobes by which they touch, the lobes decreasing in size as the distal carinal plates of the disk broaden. The other plates of disk are roundish or slightly hexagonal and closely fitted together; those of the ray are rectangular.

The superomarginals, 44 to the ray in the type, are all broader than long, as in *ctenipes*, the fourth or fifth being the widest, beyond which they very gradually decrease in breadth, being separated by but a single series of flat granulose plates, wider than long for about half the ray, and square or slightly longer than wide on the outer half. There are 56 to 63 of these plates in the 2 largest specimens, and they vary from a trifle less to a shade more than half as wide as the adjacent superomarginal. The granules are spaced more than their width and are similar to those of the superomarginals. The superomarginal granules are rather deciduous, truncate, roundish, and spaced one-half to decidedly more than their own diameter, especially distally. One can count 8 to 10 granules in the length of a plate, not including the very regular peripheral series bounding the narrow well-marked groove between the plates. Terminal plate obovate, granular.

The inferomarginals correspond to the superomarginals and on the rays are narrower. Beyond the third or fourth plates they are in contact with the adambulacrals, and 13 of the latter correspond to 10 inferomarginals at the middle of the ray. The plates are covered with small granules, rather widely spaced on the inner third of the plate; and judging by Sladen's figure (pl. 53, fig. 2), much smaller, more spaced, and less squamiform than in *ctenipes*. The granules are shorter in proportion to the width and in form are somewhat thimble shaped, the ends being sometimes swollen. The plates have 6 to 10 slender, sharp spinules arranged in a zigzag series or 2 irregular series the whole width of the plate and decreasing slightly in length from the inner to outer sides of the plate. They are two-thirds to about the length of the outer end of the first plates and decrease in number distad, there being 3 or 4 at the middle of ray, then 2, a single spinule persisting to near the end of the ray. As they are very deciduous, their presence on the outer part of the ray can be detected usually only by the scar. These spinules are more numerous and conspicuous and are distributed much farther along the ray than in *ctenipes*.

Actinal interradial areas increasing in size with age; in the largest specimens the plates extend aborally 3.5 to 4.5 inferomarginals, and there are 5 chevrons, without an odd interradial plate at the apex. Plates covered with uniform spaced, small, clavate, papilliform spinelets bent toward the margin. Nearly all the plates of the 2 chevrons nearest the furrow, and a variable number in the other 3 also (sometimes nearly all, sometimes 2 or 3 only) bear a slender, sharp, appressed spinule directed toward the margin. These are usually absent in specimens in which R is less than 50 mm. The spinules are absent in *P. ctenipes*, but the type is smaller than any specimen of *hypacanthus*, which has them well developed.

Adambulacral plates similar to those of *ctenipes*, but narrower, those of the disk being about as wide as long, except the first 3 or 4, which are increasingly wider than long as the mouth is approached. On the outer part of ray the plates are longer than broad. Furrow spines 7 or 8, the laterals round tipped with flat side to furrow, the 1 or 2 mesial spines with the edge thereto, as in *ctenipes*. The transverse margins of the plate are armed with 5 to 8 subterete spinelets, sometimes slightly compressed near the furrow, interlocking with those of the next plate over the suture. On the ray this number is reduced to 2 or 3 (occasionally upward of 5), and they do not interlock. The large specimens have proximally 2, rarely 3, prominent, tapering, sharp spines, about as long or a little longer than the plate, arranged in a transverse series. On the distal half of ray there is but 1 to a plate. Five to 8 or 9 small spinelets, like those of the actinal intermediate plates, are scattered on the surface. Specimens having R less than 60 mm. usually have but 1 subambulacral spine, though occasionally 2 proximally.

The mouth plates are substantially as described by Sladen for *P. ctenipes*, but there is an odd tooth at the inner end of the combined mouth plates, which he probably overlooked, as it is not so prominent as in *Pseudarchaster*.

Madreporic body surrounded by 7 or 8 plates, larger than the adjacent basal plate, and situated halfway between center of disk and inner edge of superomarginals; ridges relatively few, irregular, slightly branched, and radiating from center.

Anatomical notes.—Hepatic cocca short, confined to disk; stomach with one chamber; intestinal cocca 8 or 9 parted, the lobes short, irregular, sublanceolate in form, with slight marginal lobules. Gonads in a single tuft, on either side of the membranous interbrachial septa near the margin. Superambulacral plates elliptical, closely superimposed on the actinal intermediate plates and only touching the ambulacral ossicles. They are about half as long as the lower end of the ambulacral plates, are covered with tissue, are invisible unless treated with caustic potash, and do not extend beyond the fourth inferomarginal.

Type.—Cat. No. 30536, U.S.N.M.

Type-locality.—Station 5273, off western Luzon, 27 miles southwest Corregidor Light, 114 fathoms, mud, shells, and coral sand; 1 specimen.

Distribution.—From Lingayen Gulf, west coast Luzon, to Cebu and Bohol, Philippine Islands, 114 to 172 fathoms, on green mud, gray mud, sand and mud, and globigerina. Temperature range, 52.3° to 59°.

Specimens examined.—Thirty-three, in addition to the type.

Station.	Locality.	Depth.	Nature of bottom.	No.	Bottom temperature.
		Fathoms.			° *F.*
5117	Balayan Bay, southern coast Luzon	118	....	2	....
5197	Off western Bohol, 22 miles north Baliscasag Island	174	Green mud	3	54.3
5265	Batangas Bay, Luzon	135	Sand, mud	4	....
5411	Between Cebu and Bohol	145	Green mud	4	55.2
5412	.....do	162	.....do	2	54.8
5416	.....do	150	.....do	1	54.4
5417	.....do	165	Gray mud, sand.	4	54.4
5419	.....do	175	Green mud	6	54.5
5420	.....do	127	....	6	59
5440	Mouth of Lingayen Gulf, west coast Luzon	172	Fine gray sand, globigerina.	1	52.3

Remarks.—*Paragonaster ctenipes* was dredged by the *Challenger* in the Arafura Sea between the Ki Islands and Banda Islands, in 140 fathoms, blue mud. Although no intergrading forms between it and *hypacanthus* have been found, the very close similarity between the two seems to indicate a conspecific relationship. At the same time, in spite of minor variations, the special characters of *hypacanthus* are constant in mature examples, over a considerable geographical area.

PARAGONASTER STENOSTICHUS Fisher.

Plate 60, fig. 2; plate 70, fig. 2; plate 71, fig. 1; plate 91, figs. 10, 10*a*.

Paragonaster stenostichus FISHER, 1913*a*, p. 627.

Diagnosis.—Differing from *P. ctenipes* in having the abactinal plates of slender portion of ray, narrower than long, and proximally narrower than the adjacent radial plates of disk, instead of broader; in having more numerous, crowded, and coarser central granules, and slenderer peripheral granules; and in having narrower adambulacral plates, lacking the characteristic fasciolate pedicellaria of *ctenipes*, except in a less specialized form on the first few plates. R=45 mm., r=12.5 mm., R=3.6 r; breadth of ray at midinterbrachium, 14 mm.; at distal margin of fourth superomarginal (the proximal end of the slender portion of ray), 8 mm., or length of first 5.5 superomarginals measured on ambitus.

Description.—Abactinal area pentagonal or arcuate pentagonal; abactinal plates comparatively large, all strongly tabulate and paxilliform, arranged very regularly in close-set rows parallel to the radial series, and also in series proceeding obliquely from the radial series to margin. Radial plates the largest, increasing slightly in size distad up to the point where the adradial series end, and only the radials separate the superomarginals. Here they become narrower, longer than wide and continue to decrease very gradually in size to the end of ray. Moreover, these plates are slightly tabulate, proximally, with a well-defined groove separating them from the marginals, and the granules of the slightly convex crown are similar to those of the radial plates of the disk, although the crown itself is of different form, being oblong or elliptical. In *P. ctenipes* and *P. ctenipes hypacanthus* the radial plates of the ray are abruptly wider than those of adjacent portion of disk, always conspicuously wider than long proximally, flat, not at all tabulate, and are covered with spaced, small granules, precisely like those of the abactinal plates. The paxillar crowns on disk are subhexagonal to roundish, slightly convex, and in the radial series have 18 to 25 close-set, coarse, irregularly polygonal central granules and 20 or 25 much smaller, slenderer, unequal peripheral ones, usually in the form of tiny spinelets. Near the margin the central granules are reduced to 5, 6, 7, or even to 2 or 3 on plates adjacent to the marginals. The primary basal plate adjacent to the madreporic body is the largest on disk and has 35 or 40 central granules.

Papulae restricted to oval or subcircular radial areas, not reaching the beginning of narrow part of ray. The plates of the radial areas are strongly stellate with 6 pointed lobes which touch those of the neighboring plates. The other abactinal plates are roundish to subhexagonal and rather tightly fitted together.

Superomarginals 28, massive, well-arched, and tumid on disk, slightly tumid on ray, all wider than long, increasing in width as well as in length up to the fourth and fifth, thence decreasing very gradually in width, and even less rapidly in length up to end of ray. In the type the superomarginals from the fifth plate on are separated only by the radial series of abactinals; in small specimens from the third on. Width of first plate equal to length of first 3 measured on ambitus. The lateral face of plates is low, half or less than half the width of dorsal facet, the margin of the ray and disk being evenly rounded, and owing to the slight tumidity of the plate, each is very distinct, the ray appearing constricted at the transverse sutures, or "cingulate," as if the ray were jointed. This is especially marked in small specimens. Plates covered with closely placed, polygonal, rather coarse granules, about the size of those on center of abactinal plates, the peripheral series being considerably smaller, quite regular, and truncate. On the first plate 7 granules can be counted from one transverse margin to the other, including the peripheral series; these increase to 10, 11, or 12 on the fifth and a few succeeding plates. Terminal plate rather small, obovate, or chordate, granulate.

Inferomarginals corresponding to superomarginals, the first 2 very wide, equaling the length of first 3.5 plates measured on ambitus; beginning with the third they decrease very rapidly in width until at the seventh or eighth they are only as wide as long, retaining approximately these proportions to the end of the ray. Sometimes the distal plates are slightly longer than wide, especially in small examples. The plates are slightly tumid, arched, and form an evenly rounded margin to the actinal area, as much, or more, of the plate facing laterally as ventrally on the ray. Plates covered with compact granules, subquamiform ventrally. In addition to these the plates of first third or half of ray bear on their inner or lower half or third 2 or 3 short appressed lanceolate spinules, 2 or 3 times as long as the granules, and arranged in a transverse series or in a group, these becoming reduced soon to but a single spinule. Ten inferomarginals at middle of ray correspond to 14 adambulacrals.

Actinal interradial areas rather small, the plates adjacent to adambulacrals much the largest and extending to middle of third inferomarginal. The first plate extends nearly halfway from outer end of mouth plate to inner edge of marginals, about 3 irregular chevrons filling in this remaining space; no sign of an odd interradial series. Plates covered with papilliform, spaced spinelets, about the length of the inferomarginal granules but less flattened and quamiform. On the interradial suture, between the 2 plates adjacent to outer end of mouth plates, is a fasciolate pedicellaria with 8 to 10 shorter, tapering, blunt spinelets in each of the closely juxtaposed combs.

Adambulacral plates as wide, or only a trifle wider, than long, with an angular furrow margin, but up to about the fifth the aboral facet of the angle is so much longer than the adoral that the apex is close to the proximal edge of the plate, and the comb of 7 or 8 slightly flattened round-tipped furrow spines is largely oblique. Beyond the fifth plate the apex is near but not quite at the middle, and the furrow comb is palmate, the median spines being slightly compressed, while the others are nearly terete or slightly flattened with side to furrow, and decrease in length regularly to the lateral spines, which are only one-third to one-half the length of the mesial. Subambulacral spinelets terete or swollen, blunt, 12 to 15, and increasing in length from the outer edge, where they are subequal to the actinal intermediate spinelets, to a row or group of 3 to 5 spaced from the furrow spines and one-half to two-thirds the length of the mesial. Near the outer side of the plate is a stout, sharp, tapering subambulacral spine a little longer than the mesial furrow spine and directed toward the margin.

Mouth plates narrow, with a prominent angle at mouth of furrow, the margin toward the furrow being concave and having 5 or 6 spines decreasing slightly in length toward the angle above mentioned. The other facet, facing the actinostome, bears 2 or 3 additional spines which continue the series and increase in size to the median, odd, stout, terete, bluntly pointed tooth. About 10 slender terete, blunt spines follow the median suture margin and decrease in length as they proceed outward, the outer 3 or 4 spines sometimes meeting those opposite, and forming an incipient fasciolate pedicellaria. Two or three additional spines form an intermediate series near the middle of plate. About 6 small spines stand on the margin adjacent to first adambulacral, and form an incipient fasciolate pedicellaria with the adjacent adambulacral spines.

Madreporic body small, with coarse ridges and overhung by 3 to 5 paxillae. It is situated about halfway between center and inner margin of superomarginal plates.

Gonads well developed, in a single tuft, on either side of interbrachial septum near margin.

Type.—Cat. No. 30537, U.S.N.M.

Type-locality.—Station 5289, Verde Island Passage, north coast of Mindoro, 172 fathoms, broken shells, sand; 7 specimens.

Distribution.—Known only from Verde Island Passage, between Luzon and Mindoro, 172 to 198 fathoms.

Specimens examined.—Eight; 7 from type-locality and 1 from station 5297, Verde Island Passage, off Batangas Bay, Luzon, 198 fathoms, mud, sand.

Remarks.—This species is readily distinguished from *P. ctenipes hypacanthus* by the shorter, stouter rays; narrower radial plates of the ray; by the higher plates of the extra-papular areas, and by the peripheral granules of the same being uniform with those of the papular areas; by the slightly tumid marginals with their compactly placed granules; by the fewer and more restricted inferomarginal spinules, absence of actinal intermediate spines, and interadambulacral fasciolar pedicellariae (except on a few proximal plates). The superomarginals and interbrachial inferomarginals are broader in *P. stenostichus*, and the granulation throughout much more compact.

The very narrow radial series of plates on the ray is one of the most striking features of this species. *P. formosus* Verrill has lower and smaller abactinal plates with much fewer and coarser granules, especially in the peripheral series, and the marginal granules are fewer, coarser, and less compact. The same differences will separate *P. subtilis* Perrier. *P. strictus* and *P. elongatus* Perrier are closely related to *P. subtilus*. *P. cylindratus* Sladen has narrow radial plates on the ray, but in proportion to the breadth of the superomarginals they are wider than in *stenostichus*. In *cylindratus* the adambulacral furrow margin is less strongly angular, the special subambulacral spine or spines much smaller and nearer the furrow, and the inferomarginal spines more numerous.

Genus PERISSOGONASTER Fisher.

Perissogonaster FISHER, 1913*a*, p. 628. Type, *P. insignis* Fisher.

Diagnosis.—Differing from *Paragonaster* in having an odd interradial marginal in both series, and an incomplete odd interradial series of actinal intermediate plates; papulae distributed all over disk and as far along radii as the adradial plates extend.

This curious genus bears about the same relation to *Paragonaster* that *Prionaster* bears to *Goniopecten*, or *Pectinidiscus* to *Ctenodiscus*. In all the characters except those mentioned in the diagnosis it is essentially similar to *Paragonaster*.

PERISSOGONASTER INSIGNIS Fisher.

Plate 73, fig. 1; plate 74, fig. 2; plate 91, figs. 8, 8*a*.

Perissogonaster insignis FISHER, 1913*a*, p. 628.

Diagnosis.—Similar in general appearance to a *Paragonaster*, with unusually large disk, stout rays, and the adradial plates extending in large specimens a third to two-fifths length of ray. R=113 mm., r=35 mm., R=3.2 r; breadth of ray at midinterbrachium, 40 mm., thence tapering gradually to the bluntly pointed extremity; interbrachia wide and arcuate; superomarginals 37 to 42, broader than long, and increasing slightly in width up to the tenth or twelfth, and beyond the eighth to seventeenth separated only by the rectangular carinal plates; odd interradial plate similar to the rest; plates covered with depressed, roundish, convex, slightly spaced granules, the outer end being armed with an inconspicuous, short, appressed, slender, sharp spine extending nearly to end of ray; inferomarginals narrower on outer two-thirds of ray than superomarginals and covered with conical granules; in addition to these, proximally 6 to 10 and distally 2 to 4 slender, sharp, appressed spines, either scattered or in 1 or 2 transverse series; abactinal plates paxilliform, with compact subhexagonal crowns, very regularly arranged in series parallel to the radial; an average radial plate with 9 to 12 roundish or slightly polygonal, spaced, central granules and 20 to 25 flattened, truncate, oblong, or slightly tapered, smaller peripheral ones, these numbers increasing on the distal carinal plates and decreasing on the dorsolaterals; papulae distributed all over dorsal surface as far distad as there are more than 1 series of abactinal plates; actinal intermediate plates, each with an appressed, sharp spine; adambulacral plates with an angular but not very salient furrow margin bearing 6 or 7 short, blunt spines; subambulacral spines 1 or 2, sharp, appressed, surrounded by 5 to 8 elongate, subconical granules, in addition to 3 or 4 on outer margin, and 3 to 6 on each transverse margin, the latter often forming a fasciolate pedicellaria over the suture.

Description.—The rays taper somewhat arcuately from the midinterbrachium and in form are more like those of *Pseudarchaster* than the usual very attenuate condition of *Paragonaster*. Area of abactinal plates broadly stellate, or in small specimens stellato-pentagonal. All abactinal plates tabulate and paxilliform, with compact subhexagonal crowns arranged in regular series parallel to the median radial, and decreasing gradually in size along oblique series extending from the radii to the margin. Distally the radial plates become conspicuously broader, rectangular, the width decreasing much more rapidly than the length, so that the plates, which are broader than long, or square, at the beginning of the attenuate portion of ray, become distally ordinarily considerably longer than wide. The series of plates parallel to the median radial are successively shorter, proceeding from the carinal series outward, so that beyond the eighth to eighteenth superomarginal plates (not counting the odd one) the latter are separated only by the single series of rectangular plates covered with low convex, roundish, slightly spaced granules, uniform with those of the superomarginals. A carinal plate from near the primary radial has 9 to 12 roundish or slightly polygonal spaced central granules and 20 to 25 flattened, truncate, oblong, or slightly tapered smaller peripheral ones arranged with considerable regularity and ordinarily longer than broad. On the outer end of the series, just before the adradial plates end, the central granules are 25 to 30 and the peripheral about 35 and similar to the central. On the lateral plates the number of central granules decreases from about 8 or 9 on the proximal adradial plates to 3 to 6 near the margin, the smaller number being on plates near the interradius.

Papulae distributed all over the abactinal surface and as far along ray as there are more than 1 series of abactinal plates. The abactinal plates are circular, with 6 regular shallow indentations, and touch by the very short, broad truncate lobes. Near the margin the lobes are a little more pronounced.

Marginal plates with an odd interradial in both series, similar in form and size to the others, though occasionally a trifle longer than the 2 immediately adjacent. The superomarginals form a bevel and have a very low lateral face. The width increases, or has the appearance of increasing slightly up to about the eighth or tenth plates (according to size) and from that point very gradually decreases, all the plates being wider than long. The length of the plates very gradually increases up to the tenth or twelfth, and then as gradually decreases. The width of the odd plate equals its own length plus that of the first 3 superomarginals, measured on ambitus. Superomarginals 37 to 42 to the ray in large specimens. The plates are covered with roundish, depressed, convex, slightly spaced granules about the size of the central paxillar granules, and uniform on the abactinal surface, but becoming a trifle longer on the lateral. Proximally 5 or 6 granules can be counted in the length of the plate, this increasing to 9 or 10. In addition, the plate is surrounded by a regular series of considerably smaller granules, and on the outer end of the plate is a slender, sharp, appressed, inconspicuous spine, one-third to one-half as long as the plate, and persisting for two-thirds to three-fourths the length of ray. The base is swollen, and the distal portion abruptly slenderer. Two smaller specimens from stations 5118 and 5363, having R 66 mm., lack this spine, which is also usually absent from the odd plate and the first 2 or 3 plates of each ray. Terminal plate obovate, granulate.

Inferomarginals, corresponding to superomarginals, of about the same width in interbrachium, but much narrower on the ray, those of the distal half or third of ray being either slightly wider than long or, in a specimen from station 5537, slightly longer than wide. They are rather evenly arched from the inner to outer margin and are covered with slightly spaced, conical or acorn-shaped granules, a trifle larger than those of the superomarginals, the marginal series being a little smaller and the fasciolar channels very narrow and shallow. The proximal plates have 6 to 10 slender, appressed spines, similar to the superomarginal spines, and scattered from the inner margin to the lateral face of the ray or in 1 or 2 fairly definite series, the number decreasing gradually to 2 to 4 on the outer part of the ray, or 1 in smaller specimens, the last half dozen plates usually lacking the spinule. The marginal spines are always appressed flush with the surface of the plate, often lying between the granules. In many cases they taper evenly to a sharp point without being constricted about the base.

Actinal intermediate areas large, the plates elongate, in irregular series extending from adambulacral to marginal plates, and reaching distad as far as the ninth inferomarginal of type. Corresponding to the unpaired inferomarginal there are 2 series, the inner end of each abutting against the third adambulacral. Inclosed between the two are a couple of incomplete (short) series opposite the second adambulacrals, these in turn inclosing a longer and incomplete unpaired series. The latter is irregular, and proceeds from the meeting point of 2 plates, one back of each first adambulacral plate. In the type this unpaired actinal intermediate series reaches to within 2 plates of the margin, the outer end being crowded between the outer ends of the 2 series which extend from each third adambulacral to the unpaired inferomarginal. Plates low, and covered with subconical, rather irregular, skin-covered granules which become slenderer on drying; and with a central appressed sharp spinule similar to the inferomarginal spinules.

Adambulacral plates with a slightly angular furrow margin, bearing 6 or 7 short, blunt, robust spines, the mesial often slightly compressed, the others irregularly 4-sided in section and stouter. The distal edge of the comb is convex. Along the transverse margin of the plate are 3 to 6 short granules, often pressed against their fellows of the adjacent plate. One or 2 sharp tapering appressed spines, similar in form and size to those of the actinal intermediate plates, stand on the actinal surface, surrounded by 5 to 8 elongate subconical granules, or short, robust spinelets, with 3 or 4 spaced granules on the outer margin. About 3 subambulacral spinelets longer than the rest often form a series spaced from and parallel to furrow series, between it and the subambulacral spines. The plates are slightly wider than long, the first 3 or 4 being decidedly wider than long.

Mouth plates narrow with 4 or 5 short, sharp, furrow spines, increasing in size toward the median unpaired tooth. Following the margin adjacent to first adambulacral plate are 9 or 10 spines, which are soon reduced to granules on the outer part of plate, while close to them about an equal number follow the median suture margin, becoming enlarged into sharp spines at the inner end of the plate near the furrow spines, between which and the superficial spines there is a row of 3 or 4 intermediate spines.

Madreporic body rather small, crowded between the pedicels of plates and nearly hidden, situated a little over a third the distance from center to under edge of superomarginals.

Gonads in a single tuft on either side of the interbrachial septum, near the margin. Superambulacral plates present, touching the lower end of the ambulacral plates, the rest of the plate lying upon the actinal intermediates.

Type.—Cat. No. 30538, U.S.N.M.

Type-locality.—Station 5113, Balayan Bay, southern Luzon, 159 fathoms, dark green mud.

Distribution.—Balayan Bay, Luzon, to Mindanao Sea, 159 to 254 fathoms on dark green mud; bottom temperature 50.2° to 53.5° F.

Specimens examined.—Six, the type and 1 from each of the following stations:

Station 5116, mouth of Balayan Bay, Luzon, 200 fathoms, bottom not recorded, bottom temperature 50.2° F.

Station 5118, Balayan Bay, Luzon, 159 fathoms, dark green mud.

Station 5363, Balayan Bay, 180 fathoms, bottom not recorded.

Station 5530, between Siquijor and Bohol [mistake in labeling, as this was an intermediate haul].

Station 5537, between Negros and Siquijor, 254 fathoms, green mud, bottom temperature 53.5° F.

Subfamily GONIASTERINAE Verrill,[1] 1899 (extended).

Genus ROSASTER Perrier.

Rosaster Perrier, 1894, p. 386. Type, *Pentagonaster alexandri* Perrier.—Fisher, 1911, p. 164; 1913*a*, p. 629.

Nereidaster Verrill, 1899, p. 186. Type, *Nymphaster symbolicus* Sladen. [Not *Nereidaster*, Fisher, 1911*d*, p. 170, which as used here is synonymous with *Ceramaster*. I had not then seen the type of the genus which has not the anatomical characters given in the key.]

Diagnosis.—Goniasteridae resembling *Mediaster* in having internal supplementary ossicles connecting the abactinal plates and in having the gonads arranged in series extending along the rays, but differing in lacking rudimentary superambulacral ossicles, and in having the superomarginals in contact medially over a considerable portion of the ray (if separated, then only by a single series of small plates for a considerable distance); pedicellariae always slender, tong-shaped, not of the low-bivalved form. Resembling *Nymphaster* in form but differing in the serial arrangement of gonads, in having strongly tabulate subpaxilliform abactinal plates, and in lacking the strongly angular furrow margin to the adambulacral plates. Form stellate, with well-developed rays; superomarginals in contact distally, sometimes for a considerable portion of ray; abactinal plates strongly tabulate on papular areas and with internal radiating connecting ossicles; actinal interradial areas large; adambulacral plates with a straight or slightly curved furrow margin bearing a regular comb of few to many, usually compressed, spines, and spaced from these a subambulacral series of spines, more or less prismatic, the outer part of the plate being occupied by granules sometimes graduated in size toward the subambulacral series of spines; pedicellariae rather slender, spatulate, and intrenched; no superambulacral ossicles; gonads in several independent tufts which extend in a series along the ray, close to, or removed from, the margin and usually parallel to the radius; tube feet without deposits.

Remarks.—The three species which I have placed here under the genus *Rosaster* agree in having the characters mentioned in the diagnosis above, and in these respects differ from *Nymphaster*, *Mediaster*, and *Ceramaster*, the most nearly related genera.

I have long suspected that *Rosaster alexandri* might be allied to the section of *Nymphaster* called *Nereidaster* by Verrill in 1899. But

---

[1] See Fisher, 1911*d*, pp. 160, 161, 196. The subfamily is used here in the same sense. Verrill (1914*a*, p. 294) believes that *Mediaster* should be placed in the subfamily Mediasterinae on the basis of the existence of radiating internal ossicles connecting the bases of the abactinal plates. *Rosaster* would probably be placed in the same subfamily, although differing in lacking superambulacral ossicles. *Mediaster* and *Ceramaster* are difficult to separate on external characters, and can be easily confused unless they are dissected. It seems rather unnecessary to place in separate subfamilies two genera which can be distinguished only by an expert. Some of the species of *Rosaster* have up to now been included in *Nymphaster*, and in "*Nereidaster*," both supposedly typical Goniasterinae.

Sladen published no anatomical notes. In 1906 I raised *Nereidaster* to generic rank, including in it a species (*Nereidaster bowersi*) which proves not to be congeneric with the type of *Nereidaster*. It is this misconception of *Nereidaster* which I incorporated into a key to the genera of Goniasteridae in the Asteroidea of the North Pacific. 1911*d* (p. 170).

I made a cursory examination of *Rosaster* several years ago and thought I found rudimentary superambulacral plates. These are not present. What I saw, on closer examination, proves to be curious spiny outgrowths from the lower end of the ambulacral ossicles. The arrangement of the gonads and the presence of abactinal internal ossicles, similar to those of the species herein described, in addition to external similarities, leave no doubt that *Nereidaster* and *Rosaster* are the same. The external appearance of *R. alexandri* is much like *R. nannus*, and even more like *R. confinis* (Koehler), especially with regard to the abactinal surface.

The specimen of *Rosaster alexandri* (from off Barbados, 103 fathoms) which I examined has R only 16 mm., yet the gonads are well enough developed to show the serial arrangement. There are 4 of them in each series, the innermost being near the interradial septum and on the outer side of the row of plates next the adradial. The series follows this row to the margin (only a short distance), and is then bent inward by the marginal plates. The structure of the gonad resembles that of *R. nannus* and *R. symbolicus*, being a simple ovoid sac, or a small cluster of sacs. Sometimes these show an incipient lobing, but it is slight. The other internal diagnostic feature is well developed. Two rows of abactinal plates on either side of the median radial are provided with internal radiating ossicles. The median radial plates may have 5 to 8 ossicles. Two plates have the longitudinally directed ossicles (those connecting consecutive plates of the same series) split in two, making with the 2 lateral ossicles of each side a total of 8. The other plates have 5 or 6. The ossicles are longer and slenderer than in *R. nannus*. The intestinal coecum is divided into long fingerlike sacs, interradial in position. The coelomic side of the ambulacral plates is raised into a thin carina, from which arise numerous extremely delicate and fairly long spiny projections, best developed on the proximal plates, and on each plate at the lower end, although there are a variable number along the whole length of the plate. At the lower end of the plate they resemble a tuft of tiny calcareous hairs. In *R. nannus* the plates are similarly produced into a thin knifelike edge on the coelomic side, this edge separating consecutive ampullae, and showing occasional short spinelike projections, or even appearing like a saw, but never with the extraordinary delicate hairlike projections of *R. alexandri*. In *R. symbolicus* the plates are keeled, the edge of the keel being very thin, uneven, and rough but not spiny. In *R. mimicus* there is no keel.

As there are 2 names in the field for the same group, I have examined the species with the idea of instituting two subgenera. About the only characters I find are as follows: *Rosaster* (including *alexandri*, *nannus*, and perhaps *confinis*) is small and the gonads are rather closer to the margin, although this may be due to the fewer abactinal plates, especially of the interradial regions. The adambulacral spines are generally few—4 to 7 or 8 or, leaving out *confinis*, 4 or 5. In *Nereidaster* (including *symbolicus*, *bipunctus*, and *mimicus*) the size is larger. The gonads are spaced from the margin in a line parallel to the median radial (but this is strongly indicated in *R. alexandri*), and the furrow spines are numerous—8 to 15. In the present state of our knowledge I do not feel justified in advocating this distinction. I fancy the slight difference in the gonads will break down when more species are examined, and the difference in the number of furrow spines is bridged over by *R. confinis*, which is intermediate between the extremes. Even *R. symbolicus* may have as few as 8.

It should be mentioned in this connection that *R. alexandri* differs from the other species, with the possible exception of *R. confinis*, in having more spiniform granules on the abactinal plates, these being thorny and 1.5 to 2 times as long as wide, blunt, or pointed. The furrow and subambulacral spines are unusually long. One of the latter is generally enlarged over the other 1 or 2. These characters may be of considerable importance, but they seem too slight for a generic division. In *Mediaster tenellus* Fisher a somewhat analogous elongation of the granules into short spinelets has taken place.

Nymphaster protentus approaches this group rather closely, but it is useless to speculate on external resemblances. The arrangement of the gonads and the internal structure of the abactinal skeleton is unknown.

Nymphaster florifer possibly belongs to *Mediaster*. The internal anatomy is not known.

The following synopsis will contrast the differences between *Nymphaster*, *Rosaster*, *Mediaster*, and allies:

a^1. With internal radiating ossicles connecting the strongly tabulate plates of the papular areas; gonads three to many arranged in series parallel to the radius, or following the contour of margin.

  b^1. With calcified interbrachial septa, supplementary internal actinal intermediate plates, unusually large, and fewer abactinal plates, and large triangular papular areas .... *Nectria*.

  b^2. With membranous interbrachial septa, no internal actinal intermediate plates, and with moderate or small abactinal plates and papular areas.

c^1. Rudimentary superambulacral plates present; several series of abactinal plates extending to near end of ray, and normally one or more series reaching the terminal plate ---------------------------------- *Mediaster.*

c^2. No rudimentary superambulacral plates; distal superomarginals usually in contact, forming a slender, pointed ray, or if not in contact, separated for a considerable distance only by a single series of reduced abactinal plates ---------------------------------- *Rosaster.*

a^2. Without internal radiating ossicles connecting the abactinal plates; gonads always interradial in position.

b^1. General form pentagonal or stellato-pentagonal with very short rays; abactinal plates of papular areas tabulate; superomarginal plates not contiguous on the rays, one or more series of abactinal plates reaching the terminal plate (occasionally a few distal plates in contact medially); adambulacral plates with a straight or curved furrow margin and with a series of subambulacral spines spaced from the furrow spines, but no strongly angular furrow margin separating consecutive pairs of tube-feet ---------------------------------- *Ceramaster.*

b^2. General form stellate with long slender rays; abactinal plates granulate but not tabulate, although sometimes a trifle raised; superomarginals contiguous throughout the long slender rays; adambulacral plates with (at least distally) a strongly angular furrow margin, and angular furrow series, separating consecutive tube-feet; no regular comb of subambulacral spines spaced from furrow series (although sometimes the inner subambulacrals are enlarged) ---------------------------------- *Nymphaster.*

It will be seen from this table that *Nymphaster* is rather sharply set off from *Rosaster* by the low abactinal plates lacking internal supplementary ossicles, by the strictly interradial gonads (1 tuft), and by the characteristic form of the adambulacral plates and armature. The principal likeness between the two groups is in the long, slender rays and contiguous superomarginals.

KEY TO THE KNOWN SPECIES OF ROSASTER.

a^1. Superomarginals contiguous for nearly half to more than half of R; not separated by a single series of small plates for a considerable distance.

b^1. Furrow spines 4 or 5, at least few in number; size small.

c^1. Abactinal paxilliform plates roundish, with subequal, thorny spinelets; granules of marginal plates longer than diameter, thorny and resembling very short spinelets; furrow spines relatively long, slender, compressed ---------------------------------- *alexandri.*

c^2. Abactinal plates hexagonal, with unequal granules, the peripheral on the lateral edges of the radial and adradial plates being enlarged and opercular, covering the papulae beneath; granules of marginal plates small, depressed, hemispherical, broader than high; furrow spines short ---------------------------------- *nannus*, p. 244.

b^2. Furrow spines 7 or 8 to 14 or 15; size small to large.

c^1. Size small; radial tabulate plates roundish, a few distal abactinal plates isolated singly between consecutive pairs of contiguous superomarginals; furrow spines 7 or 8; subambulacral spines and granules in 3 series ---------------------------------- *confinis.*

c^2. Size medium or large; radial tabulate plates hexagonal.

d^1. Furrow spines 14 or 15; large radial plates with 12 to 23 central granules ---------------------------------- *mimicus*, p. 250.

d^2. Furrow spines 8 to 10; large radial plates with 2 to 4 central granules -- *bipunctus*.

a^2. Superomarginals separated on outer part of ray by a single series of abactinal plates, but the last few plates may be in contact medially.

b^1. Size small; distal marginals with a small central tubercle; marginals tumid; furrow spines 4 or 5-------------------- *mamillatus*, p. 247.

b^2. Size large; distal marginals not tuberculate; marginals not individually tumid; furrow spines 8 to 12-------------------- *symbolicus*, p. 253.

ROSASTER NANNUS Fisher.

Plate 61, figs. 1, 2; plate 68, fig. 6; plate 91, figs. 3, 3*a*.

Rosaster nannus FISHER, 1913*a*, p. 631.

Diagnosis.—A small species resembling *R. confinis* (Koehler), but differing in having larger, hexagonal, radial plates, with differently formed and characteristic marginal granules, fewer furrow spines (4 or 5) and 2 instead of 3 series of subambulacral spines and granules. Disk stellato-pentagonal, the rays at first tapering abruptly to the third superomarginal, which meets its fellow medially, then very gradually, the extremity being blunt and the general form resembling that of *Paragonaster;* breadth of ray at inner end of third superomarginal equaling first 2½ superomarginals measured on ambitus; radial plates large, with large, valvelike granules on the lateral borders, and smaller ones on the transverse margins; furrow spines 4 or 5; subambulacral armature in 2 longitudinal series, the inner consisting of 3 or 4 spines; consecutive plates of median radial series joined by 2 internal ossicles, and joined to the adradials by 2 transverse ossicles, the former being absent on the adradial series. R=24 mm., r=6.5 mm., R=3.7 r; breadth of ray at midinterbrachium, 7 mm.

Description.—Abactinal area stellato-pentagonal, bounded by broad superomarginals (2.5 of each series). Plates strongly tabulate, even the few interradial ones being raised as much as is usual for the *radial* plates of *Nymphaster.* Median radial plates, hexagonal, wider than long, with very straight edges. Parallel to this are 2 longitudinal series of tabulate plates, the adradial plates being conspicuously smaller than the radial and the next conspicuously smaller than the adradial. Between this second series and the margin are 2 short series of lower interradial plates, forming with those of the other side of interbrachium 2 chevrons. A large proximal median radial plate has 15 to 25 central hemispherical slightly spaced granules, gradually decreasing to as few as 2, but usually 4 or 5, on the distalmost plates of the series. The peripheral granules are conspicuously larger on the lateral margins, where they are flattened, polygonal, valvelike, and trimmed to conform to the edge of the hexagon; but they decrease abruptly in size toward the middle of the transverse edges, where 3 or 4 granules are smaller than the central ones and slightly spaced. The primary radial plate has 18 to 25 peripheral granules, and the number decreases to about 10 on the distal plates. The adradial plates are similarly constructed, but have only 4 to 8 central granules proximally and 1 or 2 distally and fewer peripheral granules than have the radial plates. The second longitudinal series has the peripheral granules abutting against the adradial plates much enlarged, but the others about the size of those on the adjacent interradial plates. These plates have a curious one-sided appearance, which is more accentuated in the type than in 1 or 2 other specimens from the same station. The great difference in size between the peripheral granules of the transverse margins and those of the lateral longitudinal margins is very striking. The primary basal plates are larger than the primary radial in the type and subequal in other specimens from the same station. As mentioned above, the interradial plates are also elevated and covered with relatively few hemispherical granules, sometimes truncate on the periphery of plate. No abactinal pedicellariae.

Seen from the coelomic side, the hexagonal radial and adradial plates are joined by stout intermediate ossicles with a minutely thorny surface. Consecutive median radial plates are joined by a pair of ossicles (as in *symbolicus*), and there are 2 on either side, making 8 touching each plate. The adradial plates lack the ossicles binding consecutive plates, so that there are only 4 (the laterals) around each plate. The plates of center of disk are also joined by the internal ossicles. Papulae on center of disk and in 4 zigzag series along each radial area; 6 about each radial and adradial plate.

Superomarginal plates all longer than wide as seen from above and rather evenly and fully curved from the inner to the outer margin, the lateral face being only a trifle narrower than the dorsal. Plates 13 to a ray in type, increasing in size up to the third, which meets its fellow medially. This plate is slightly longer than wide (or the 2 dimensions subequal) as seen from above, and thence the plates are increasingly longer than wide. The first 3 plates are shorter than the chord of the extreme width, however, and in the fourth the length about equals the chord of width. Plates covered with slightly spaced, depressed subspherical granules subequal to those occupying the center of abactinal plates. The sutures between the plates are marked by well-defined grooves. Terminal plates as broad as long (or broader), blunt distally but pointed proximally.

Inferomarginals nearly or quite corresponding to superomarginals, the length of the second equal to chord of width, but all normally longer than wide as seen from below. Ten inferomarginals, beginning with the third, corresponding to 32 adambulacrals. Distal inferomarginals commonly twice as long as extreme width. Granulation similar to that of superomarginals. A small entrenched 2-jawed pedicellaria on some of the first plates of type, but not in other specimens.

Actinal intermediate plates four-sided, in 2 or 3 regular chevrons, according to the size of specimen, slightly raised, with conspicuous sutures, and covered with spaced tubercular subprismatic granules, often longer than wide and intermediate between short spines and granules. The largest have 12 or 14 of these.

Adambulacral plates small, squarish, with a nearly straight furrow margin proximally and a slightly curved one distally, but no angular projection or apophysis as in *Nymphaster.* Furrow spines 4 or 3 in small specimens, but in the type proximally 4, then 5 over the greater part of the ray, then 4 at tip, short, compressed, blunt. Spaced from these is a parallel series of 3 (proximally) or 4 stouter, slightly shorter, blunt, subprismatic to subterete subambulacral spines, the adoral the shortest when there are 4. Spaced from these is a parallel series of 3 or 4 subprismatic granules, the tip either blunt or beveled like that of a chisel.

Mouth plates with 6 compressed round-tipped marginal spines in a straight series and about 8 suboral spines and granules, 3 or 4 forming a series parallel to furrow; 2 more, slightly smaller, are parallel to these, while the outer end of the plate is occupied by 2 or 3 granules.

Madreporic body medium sized, surrounded by 5 plates (4 in young) situated about halfway between center and edge of marginals.

Anatomical notes.—Although the specimens are small, the gonads are relatively very large and fill up most of the coelom of the base of ray. They consist of thick unbranched or bifid sacs in clusters of 1 to 5, these extending in a series close to the margin as far as the third superomarginal or until these join medially. There seem to be at least 5 of these clusters in each series. The stomach is rather small. There are no superambulacral ossicles or rudiments.

Variations.—Aside from the variations referred to in the description, the proportion of R to r differs individually and according to size. In the smallest example $R=13$ mm.; $r=4$ mm.; $R=3.2\,r$; another specimen measures $R=17.5$ mm., $r=6.5$ mm., $R=2.7\,r$. A smaller specimen measures 16.5 mm.; $r=5$ mm., $R=3.3\,r$.

Type.—Cat. No. 30539, U.S.N.M.

Type-locality.—Station 5152, Tawi Tawi Group, Sulu Archipelago (lat. 5° 22′ 55″ N.; long. 120° 15′ 45″ E.), 31 fathoms, white sand; 3 specimens.

Distribution.—From east of northern Palawan to the Sulu Archipelago, 34 to 51 fathoms, on sandy bottom.

Specimens examined.—Seven; 3 from type-locality and 4 from the following stations:

Station 5432, off Corandagos Island, east of northern Palawan (lat. 10° 38′ 45″ N.; long. 120° 12′ 45″ E.), 51 fathoms, sand; 1 specimen.

Station 5433, same locality, 54 fathoms, green mud, coral sand; 3 specimens.

Remarks.—*Rosaster nannus* is probably congeneric with *Dorigona confinis* Koehler, from the Andaman Islands, 67 fathoms (1910*a*, p. 57), although nothing concerning the internal anatomy of the latter is known. I have indicated the differences in the diagnosis. *R. nannus* differs from *R. bipunctus* (Sladen) in having larger abactinal plates, which on the papular areas have peculiar and characteristic marginal granules, longer marginal plates, much fewer furrow spines. In *R. nannus* 10 inferomarginals correspond to 32 adambulacrals, while in *N. bipunctus* only 20 or 21 (according to figure).

ROSASTER MAMILLATUS Fisher.

Plate 56, figs. 3, 4; plate 61, figs. 3, 4; plate 91, figs. 5, 5*a*.

Rosaster mamillatus FISHER, 1913*a*, p. 632.

Diagnosis.—Differing from *R. alexandri*, and other small species, in having the superomarginals beyond the third plate separated by a single series of abactinal plates nearly to extremity of ray, and in the presence on the distal marginal plates of a small central tubercular granule, larger than any of the other granules. R=21 mm., r=7.5 mm., R=a little less than 3 r; breadth of ray at midinterbrachium, 7 mm. Superomarginals massive, tumid, 13 in number, and covered with roundish, rather coarse, subtruncate, slightly spaced granules, the peripheral being largest on the dorsal facet of plate; the 5 or 6 superomarginals preceding the last with an enlarged, subcentral, tubercular granule; inferomarginals corresponding to superomarginals, tumid, the last 6 or 7 with a subcentral enlarged granule. Area of abactinal plates stellate; median radial plates wider than long, subhexagonal, the others subcircular, all tabulate; granules relatively coarse, the peripheral flattened, finger-nail-shaped, 10 to 12 on the radial plates and 8 to 10 on laterals; central granules roundish, low, 2 or 3 to 6 on radial plates, 1 to 3 on lateral plates; carinal plates of attenuate part of ray small, those opposite the transverse sutures of superomarginals elliptical or lozenge-shaped, the alternate plates smaller and oblong; abactinal plates with a few upright conspicuous pedicellariae, with 2 oblong or slightly tapered jaws. Adambulacral plates with a slightly curved furrow margin and 4 or 5 subequal, slightly compressed, blunt, furrow spines; subambulacral spines 3 or 4 in an oblique longitudinal series spaced from furrow, followed by proximally 3 or 4 granules in a single series, or distally 5 or 6, usually in 2 series. Oral spines 8, similar to the adambulacral furrow spines.

Description.—Area of abactinal plates stellate, slightly inflated on the radial areas and sunken on the interradial. Plates arranged in 2 regular circles surrounding the central plate, the outer circle composed of the primary basals and radials—10 plates in all. Outside of these the plates form a regular series along each radius to within the length of 2 or 3 marginals of the tip of ray; and from the fourth superomarginal they are longer than wide, oblong, or elliptical in shape, and abut against the superomarginals of each side of ray. The last plate or two may be segregated by the superomarginals meeting medially. The other abactinal plates form 4 chevrons in the interradial region inclosed by 2 adjacent radial series. All the plates are rather strongly tabulate, except interradially near margin, and those of the 2 circles on center of disk which are low tabulate. The radial plates are wider than long and subhexagonal, the others subcircular. The granules are relatively coarse, the peripheral finger-nail-shaped, very slightly spaced and ornate, 10 or 12 in number on the radial plates and 8 to 10 on the laterals, surrounding, respectively, 2 or 3 to 6 (radial) and 1 or 3 (lateral) roundish or polygonal, sometimes slightly smaller, granules, spaced a little from the peripheral. The large primary basal plates have upward of 16 peripheral and 6 central granules. About a dozen plates, mostly adradials bear a prominent pedicellaria, with 2 upright, oblong, or slightly tapering jaws about half as long as the width of the tabulum. The plates of the series separating the superomarginals are sunken slightly below the surface of latter and are covered with mostly roundish, slightly spaced granules. An elliptical or lozenge-shape plate usually alternates with a smaller oblong one, the former being opposite the transverse sutures of the superomarginals. Papulae in oval, radial areas, reaching as far distad as the adradial plates extend, and including 5 longitudinal rows of plates.

Superomarginals 13, massive and tumid, encroaching conspicuously upon abactinal area, and beyond the third separated only by the single series of radial plates, the last 2 or 3 being in contact medially. The dorsal facet of the plate is wider than the lateral, and owing to the tumidity, which is more pronounced distally, the contour of the ray is scalloped and the margin evenly rounded, having the appearance of being constricted at the transverse sutures of the plates, which correspond on the 2 sides. The plates are covered with roundish, rather coarse, subtruncate, slightly spaced granules, those of the regular peripheral series being conspicuously larger than the others on the dorsal facet but becoming subequal on the lateral. The 5 or 6 plates preceding the last bear an enlarged subcentral, tubercular granule 2 or 3 times the diameter of the surrounding granules. Terminal plate fairly large, longer than wide, with about 4 tubercles on the end.

Inferomarginals, corresponding to superomarginals, encroach a trifle less upon the actinal area of rays than the superomarginals upon abactinal, and the proximal plates are slightly less tumid than the corresponding superomarginals. The plates are covered with granules similar to those of the lateral surface of superomarginals, and the last 6 or 7 bear a subcentral enlarged granule.

Actinal intermediate plates in 3 chevrons, the plates covered with spaced, prismatic, or four-sided granules 9 to 12 to a plate, rarely more or fewer. The plates reach to the proximal end of the third inferomarginal. In each chevron one plate is generally interradial in position, but there is usually an even number of plates in each chevron. The plate just back of the combined mouth plates is much smaller than its neighbors and has 4 granules.

Adambulacral plates about as wide as long, with a very slightly convex furrow margin bearing 4 or 5 subequal, slightly compressed, four-sided, untapered, blunt furrow spines, about as long as the plate and forming a comb with slightly divergent or parallel compact teeth. Subambulacral armature: an oblique, longitudinal, slightly curved series of 4 or 3 four-sided short spines, stouter and a little shorter than the furrow spines and spaced from them. Back of these at outer end of plate is a row of 3 or 4 elongate granules or sometimes distally 5 or 6 granules in 2 series, or forming a circle with the inner subambulacral spines.

Mouth plates small with straight furrow margin bearing 8 spines similar to those of the adambulacrals, but the inner 2 or 3 a little heavier. Parallel to these are 3 to 5 spines in line with the inner series of subambulacrals and subsimilar to them, the outer part of the plate being occupied by 6 or 7 spines and granules graded in size from the above to the actinal intermediate granules.

Madreporic body surrounded by 5 plates and situated about halfway between center and inner edge of marginal plates, with a few curved, incomplete, branched striae separated by broad ridges.

Anatomical notes.—Gonads not yet developed; intestinal coecum with bifid interradial branches; no superambulacral plates. The membranous interbrachial septa have relatively few conspicuous calcareous plates, some of them shaped like short spines which project at right angles to the septum. Ambulacral ossicles with a sharp ridge toward the coelom, which bears on the proximal plates several fine spiculiform prolongations midway between the upper and lower ends.

Type.—Cat. No. 30541, U.S.N.M.

Type-locality.—Station 5481, Surigao Strait, off Cabugan Grande Island, Leyte, 61 fathoms, sand shells, gravel; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This species agrees with *R. symbolicus* in having the superomarginals of the ray, except the last two or three, separated by a single series of abactinal plates, but differs in having conspicuously tumid marginal plates, the distal half dozen of each series bearing a small central tubercle. The furrow spines are 4 or 5 instead of 8 to 12, and the species is small while *symbolicus* is large.

ROSASTER MIMICUS Fisher.

Plate 62, fig. 1; plate 65, fig. 1; plate 70, fig. 1; plate 91, figs. 4, 4*a*–*b*.

Rosaster mimicus FISHER, 1913*a*, p. 632.

Diagnosis.—Resembling somewhat *R. bipunctus* (Sladen), but differing in having sharper rays, compacter paxillae with numerous crowded central granules, more numerous, compressed, furrow spines (12 to 14), more numerous subambulacral spines and granules, and more numerous oral spines. Form stellate with arcuate interbrachia and gradually tapering rays; sides of ray and disk perpendicular with a longitudinal depression; breadth of ray, measured at proximal suture of first pair of superomarginals which meet medially equal to first 3.5 or 4 superomarginals measured on ambitus; abactinal plates strongly tabulate on papular areas and with upward of 23 central and 25 peripheral granules on the radial series; abactinal, marginal, actinal intermediate, and adambulacral pedicellariae; subambulacral armature a series of prismatic spines and 2 or 3 parallel series of granules; furrow spines 12 to 14. R=56 mm., r=21 mm., R=2.7 r (cotype); in type R=probably 75 mm. and r=23 mm.

Description.—The general form is sufficiently shown by the photographic figure. The rays are only of moderate length, the tip of all of those of the type being missing, but the slightly smaller cotype has a perfect ray. Abactinal area stellato-pentagonal to pentagonal. Abactinal plates regular, those of the radial areas and center of disk (papular area) strongly tabulate, a radial and 3 parallel longitudinal series being symmetrically hexagonal, flat-topped, or slightly convex. A radial plate of the type has upward of 23 subcircular or polygonal flat-topped or slightly convex depressed central granules, and 15 to 25 truncate larger peripheral ones, the outer edges conforming to the contour of the pentagonal form as if dressed with a knife. The proximal plates have the largest and fewest peripheral granules. In the cotype (station 5282) the peripheral granules of the radial series range from 12 to 18 and the central, 8 or 9 to 12. The plates on center of disk are irregularly hexagonal or pentagonal with clean-cut edges. The primary basal plates are slightly larger than the largest radial plates. There are 5 or 6 chevrons of close-set, four-sided, interradial plates covered with a uniform mail of oblate spherical granules, those of the peripheral series being "trimmed" to a straight edge on the plates adjacent to the lateralmost radial series. The radial papular areas are oblong rather than lanceolate; papulae on center of disk. There are a very few slender entrenched pedicellariae, with a fairly wide base tapering into very slender jaws, on the abactinal plates, and similar ones on the dorsal and lateral surfaces of a few of the proximal superomarginals. They have no definite position on the plate.

The plates of the papular areas when examined from the inner or coelomic side are hexagonal with arcuate sides. The radial and either adradial series are joined together by internal oblong or elliptical ossicles at the corners of the plates, and each adradial series is also joined to the second longitudinal series in the same way. There are, consequently, 4 longitudinal series of the internal ossicles extending transversely between the plates and 3 series of longitudinally directed ossicles between these. As the papular area increases in size new ossicles appear, so that in the cotype there are 6 instead of 4 longitudinal series of transversely directed ossicles; these do not encroach on center of disk except in fully grown examples.

Superomarginals forming a slightly to decidedly raised border to abactinal area. They are blocklike and the angle between the dorsal and lateral faces is abrupt, swollen, and less than a right angle, there being a depression all along lateral face of disk and ray. Superomarginals increasing in size up to the fifth. Either this or the sixth meets its fellow medially; dorsal surface of first 4 plates slightly wider than long; fifth decidedly wider than long; thence the width decreases more rapidly than the length, the ninth being square and the succeeding plates slightly, then obviously, longer than wide. Height of plate interradially and on proximal part of ray slightly more than half the width of dorsal surface; near the end the 2 dimensions are nearly equal. Granules small, depressed, circular, close but not touching, similar to those on the abactinal interradial plates. Number of plates in cotype, 21 or 22. Terminal plate ovoid, pointed proximally.

Inferomarginals about as wide interbrachially as superomarginals, but decreasing regularly in width from the first plate, the fifth being about as wide as long, and the succeeding longer than wide, as seen from below. Ten inferomarginals, beginning with the eighth, correspond to 20 adambulacrals (19–21). Granulation similar to that of superomarginals. Many of the plates have 1 or 2 slender entrenched pedicellariae on the actinal surface.

Actinal intermediate plates in 5 chevrons, the outer reaching eighth inferomarginal. The plates are plane and covered with slightly spaced, convex, polygonal, or hemispherical, equal granules, the sutures between the plates being narrow but conspicuous. Many of the plates of the innermost chevron, and other scattered plates, have a pedicellaria with 2 slender, spatulate, denticulate, or entire jaws, springing from a narrow base; and sometimes they have a couple of pedicellarialike granules at one side, as in *R. symbolicus*.

Adambulacral plates at first with a nearly straight, then a slightly curved furrow margin, but without an angular apophysis. On the outer part of the ray this convexity is sufficient to separate consecutive pairs of tube feet as the plates are placed exactly opposite. Furrow spines at first 12, increasing to 14 or even 15, sharply four-sided, compressed to an even thickness, truncate, very comblike, with a nearly straight distal margin, but the 1 or 2 lateralmost are shorter. The thickness of the spines is much less than their width (in the transverse axis of plate). Separated from these by a slight space is a curved series of 6 close-set heavy four-sided spines shorter than the furrow spines and beveled from the base to tip, like a wedge. Back of these are 2 spaced rows of three- or four-sided prismatic granules, 5 or 6 to a row, these increasing to 3 rows on the outer part of ray. Thus a plate may have 25 to 30 subambulacral granules, as the first spinose series becomes gradually reduced to granules. Many plates, near their proximal end, have a stout pedicellaria composed of 3 or 4 incurved spiniform jaws modified from granules. In the type these are not very numerous, and are lacking on the outer half of ray. In specimens from station 5282 they occur on a majority of the plates, and beyond the proximal third of the ray have 2 jaws, becoming gradually transformed on the outer half of ray into the ordinary pincer with narrow strap-shaped or slightly spatulate (variable) jaws. These specimens also have the actinal intermediate pedicellariae more numerous.

Mouth plates with a straight furrow margin and 15 marginal spines, the outer 10 truncate and four-sided, the inner 5 increasing in size and becoming three-sided, compressed, and knifelike. Parallel to the furrow series are about 6 prismatic shorter, stouter spines in line with the first subambulacral series, the outer part of plate being occupied by 12 to 14 variable granules, in general like those of the adambulacrals.

Madeporic body very small, three- or four-sided, surrounded by four plates, with a fifth encroaching, and situated about one-fifth r from center.

Anatomical notes.—The gonads form a series of 5 small tufts (probably more in the larger type), which begin at the middle of the interradius and, following the fourth longitudinal series of abactinal plates, just outside of the papular area, reaches to the third superomarginal plate. This arrangement conforms with that found in *R. symbolicus* and *R. nannus*. The gonads resemble miniature bunches of grapes, and each tuft has a separate aperture. The intestinal coecum resembles that of *R. symbolicus*, but each interradial division is entire and not divided into 2 distal lobes. There are no rudimentary superambulacral ossicles.

Type.—Cat. No. 30540, U.S.N.M.

Type-locality.—Station 5281, between Lubang and Luzon (lat. 13° 52′ 45″ N.; long. 120° 25′ E.), 201 fathoms, dark gray sand.

Distribution.—Known only from the vicinity of the type-locality.

Specimens examined.—Four, the type, and 3 from station 5282, type-locality, 248 fathoms, dark gray sand.

Remarks.—I do not think this species is so closely related to *R. bipunctus* as is *R. nannus*. A small example of *R. mimicus* with R=32 mm., and therefore comparable to the type of *bipunctus* is just as different as the larger type, except that the large radial plates have upward of 12 central granules and the adambulacral plates have 12 compressed, truncate furrow spines instead of the maximum of 14 or 15 of the type.

The general appearance of *R. mimicus* is much like a *Ceramaster* or a *Mediaster*, with long rays and numerous superomarginals in contact. At the same time it greatly resembles a true *Nymphaster*, from which it is separated by the anatomical features characterizing *Rosaster*.

ROSASTER SYMBOLICUS (Sladen).

Plate 91, fig. 6.

Nymphaster symbolicus SLADEN, 1889, p. 297, pl. 50, figs. 1 and 2; pl. 53, figs. 7 and 8.

Nereidaster symbolicus VERRILL, 1899, p. 187.

Rosaster symbolicus FISHER, 1913*a*, p. 630.

Notes on Philippine specimens.—The 2 specimens differ somewhat from Sladen's figures, but agree more closely with his description, the latter not being in strict accord with the plates.

The specimen from station 5520 has 9 or more superomarginals in contact at the end of the ray. Sladen's figure shows them separated throughout the ray. But he says, on page 299: "Toward the end of the ray the paxillar plates lose their hexagonal outline and become square, and finally become so small that their serial succession is interrupted by the contact of the 2 corresponding superomarginal plates from each side of the ray. The radial series then rapidly aborts and the extremity of the ray is occupied *entirely* by the superomarginal plates." On the following page he says: "*Nymphaster symbolicus* is readily distinguished from *Nymphaster protentus* and its allies * * * by the presence of a medioradial series of plates which separate the two opposite series of superomarginal plates throughout the ray." He contradicts himself in the same way in his key, his statement being obviously erroneous there, because in *N. bipunctus* the distal superomarginals are regularly in contact and are not separated throughout the ray, as the heading of the synopsis would lead one to believe.

In the specimen from station 5520 there is some irregularity in the form of the plates, after being reduced to a single series on the ray. At first hexagonal plates alternate with squarish ones, and then the latter die out and the hexagonal plates become lozenge-shaped, and are interrupted by the superomarginals meeting medially between them. The central granules of the abactinal plates are less globular than in Sladen's figures and description. Rather they are polygonal, subtruncate, with a slight eminence in the center like a pimple or mamelon. This specimen has usually 10 or 11 compressed furrow spinelets, less often 9. Sladen gives 10, but his figures show 12 and 13.

The specimen from station 5367 has slightly shorter rays and the series of abactinal plates reaches the terminal plate. It agrees with Sladen's variety *breviradiatus* in these respects and in having a pair of enlarged pedicellarialike granules adjacent to the actinal intermediate pedicellariae, but differs in having only a few (frequently only 2) depressed subglobular granules on the central part of the tabulum of radial abactinal plates. There are two kinds of abactinal pedicellariae. One is the usual slender, entrenched forceps described by Sladen. These have compressed toothed jaws, and when the pair is closed they have a broadly elliptical form viewed from the side. The other form is not common. It consists of 2 slightly modified elongate curved granules. In this specimen the compressed furrow spines are commonly 9.

The intestinal coecum is very large and consists of a central irregular pentagonal sac about 5 mm. wide, from which 5 slender coeca extend interradially to the margin, each being divided at the middle into 2 distal portions. The stomach is small and the hepatic coeca extend about half the length of ray. The gonads are in 10 or more independent tufts, which extend along the ray about as far as the first 6 superomarginals. This condition recalls that in several Astropectinidae, as, for example, *Dipsacaster*. There are 2 Polian vesicles in the hydropore interradius and 1 in each of the others; ampullae strongly double; tube feet with strong sucking disk. Interbrachial septum membranous. No superambulacral ossicles, or rudiments.

The form of the abactinal skeleton as seen from the coelomic side is very curious. The plates are bound together by slender, irregular rods, much as in *Mediaster*, but the rods are often once branched and have tiny spinelike processes growing downward, which give to the coelomic surface of the abactinal integument a spinulose appearance, suggesting remotely the abactinal surface of some species of *Henricia* having few sharp spinelets. The plates of the radial series are slightly 6-lobed, with 6 to 8 of the rods connecting it with neighboring plates. Often there are 2 rods side by side connecting consecutive plates of the carinal series. The lateral radial plates are also lobed; but distally the lobes become obsolete. The papular areas include 4 longitudinal series of plates on either side of the median radial plates, and the rods are present connecting these. The interradial side of the fourth row is without rods, being joined rather tightly to the interradial plates which are four-sided and closely joined. The papulae are present on the center of disk, and the connecting rods are found here also. The figure will give a better idea of the exact form of the plates (see pl. 91, fig. 6), which are paralleled by those of *Mediaster*.

Type.—In the British Museum.

Type-locality.—Off Tablas Island, Philippine Group, 100-115 fathoms, green mud, *Challenger* station 204.

Distribution.—Philippine Islands to the Banda and Arafura Seas, 28 to 180 fathoms.

Specimens examined.—Two, from the following stations:

Station 5367. North coast Mindoro (Verde Island Passage), 180 fathoms, sand.

Station 5520. Mindanao Sea, off Point Tagolo, Mindanao, 102 fathoms, bottom temperature 61.3° F.

Genus MEDIASTER Stimpson.

Mediaster STIMPSON, Boston Journ. Nat. Hist., vol. 6, p. 530.—FISHER, 1911*d*, p. 196. Type, *M. aequalis* Stimpson.

Mediaster is closely related to *Rosaster*, and is separated from it by the presence of rudimentary superambulacral ossicles and by the form of the ray. Several series of abactinal plates extend nearly to the tip of the ray, the last 2 or 3 superomarginals being separated by a single radial series. Occasionally the last few plates are in contact medially, or more than 1 series reaches the terminal plate. Both genera have the internal supplementary abactinal plates and the serially arranged gonads. Both genera have species with only a few gonads to the series (*Mediaster aequalis* and *Rosaster alexandri* or *R. nannus*) and species with comparatively many (*Mediaster ornatus* and *Rosaster symbolicus* or *R. mimicus*). The internal ossicles are slenderer and better developed in *Mediaster*, having a wider distribution, in *M. aequalis* extending to the interradial septa.

Mediaster aequalis has 3 rather large tufts in each series of gonads, nearer the margin than in *M. ornatus; M. arcuatus* has 6 tufts (in the specimen dissected); *M. bairdii* has 6 tufts (in specimen dissected); *M. ornatus* has 5 to 10 tufts.

Mediaster is closely related to *Nectria*, an Australian genus. *Nectria* differs from *Mediaster* in having calcified interbrachial septa, supplementary, internal, actinal intermediate plates, relatively very large tabulate abactinal plates, fewer than in *Mediaster*, and in having large triangular papular areas on the disk, with upward of 10 or even more (as high as 18 in *Nectria ocellata*) papulae.

MEDIASTER ORNATUS Fisher.

Mediaster ornatus Fisher, 1906, p. 1046, pl. 16, figs. 3, 3*a*–*b*; pl. 20, figs. 1 and 2.—Koehler, 1909, p. 78, pl. 10, fig. 4 (Arabian Sea).

Notes on Philippine specimens.—The 3 examples, very nearly of a size, are all larger than the Hawaiian specimens and present several minor points of difference. The ray is a trifle slenderer at the tip, the abactinal plates more compact, but not necessarily larger, the actinal intermediate granules a little smaller, more depressed, and the sutures between the plates not so conspicuous or deep. The furrow spines are 6 or 7, but occasionally 5, and the series of subambulacral spines is not quite so prominent. In Hawaiian specimens the furrow spines vary from 6 to 8, and very rarely a shorter ninth spine is present. But the Hawaiian examples are rather variable in the form of the granules, compactness of plates, and in the number of spines and granules. A character not brought out in the original description and one which is exhibited by most species of the genus is the presence, on the outer attenuate part of the ray, of an enlarged club-shaped subambulacral, much longer than the furrow spines and situated in the middle of the inner subambulacral series, the other members of which are shorter than the furrow spines.

The internal supplementary ossicles of the abactinal plates are slender and overlap the plates for a third of their diameter. There is no difference between the Philippine and Hawaiian specimens in this regard. The Philippine example dissected has the gonads in a series of 10 tufts extending from the interbrachial septum (at about midway between center and margin) along the sixth longitudinal series of plates from the midradial, reaching to the fifth superomarginal. In a medium-sized (not the largest) Hawaiian specimen there are 5 or 6 tufts, reaching the fourth superomarginal. The series in the Philippine example is longer than in any species of the genus. *M. aequalis* constantly has only 3 tufts. R=78 mm., r=33 mm., R=2.33 r; another specimen, R=78 mm., r=31 mm.

Type-locality.—Station 4022, east coast of Kauai Island, Hawaiian Islands, 399–374 fathoms, coral sand, foraminifera; bottom temperature 41° F.

Distribution.—Hawaiian Islands, Philippine Islands, and the Arabian Sea, 286 to 492 fathoms.

Specimens examined.—Three from the following stations: Station 5450, Lagonoy Gulf, east coast Luzon, 408 fathoms, green mud, coral, bottom temperature 42.3°; 1 specimen. Station 5467, same locality, 480 fathoms; 2 specimens.

Genus CERAMASTER (Verrill).

Ceramaster VERRILL (Sec. C of *Tosia*), 1899, p. 161. Type, *Asterias granularis* Retz.—FISHER, 1911*d*, p. 204.

CERAMASTER SMITHI Fisher.

Plate 57, fig. 1; plate 58, fig. 2; plate 91, fig. 7.

Ceramaster smithi FISHER, 1913*a*, p. 640.

Diagnosis.—In general appearance closely resembling *C. clarki* Fisher, but differing in having less elevated abactinal plates, with shorter and differently formed basal lobes; more numerous granules, especially on center of tabulum; smaller pedicellariae; coarser and characteristically formed subambulacral spines. General form arcuately pentagonal, produced at the corners into short, blunt rays; body thin; margins thin, the plates being small as in *C. clarki;* abactinal plates very short-lobed and with hexagonal crowns on papular areas, composed of 10 to 18 central and 15 to 22 peripheral, subequal, slightly spaced granules, and often a small, spatulate, two-jawed pedicellaria; superomarginals longer than wide and with slightly spaced, flat granules, except the last few plates, which are wider than long and have a bare area; adambulacral plates with 4 or 5 coarse furrow spines and 3 coarser truncate subambulacral spines, the tips truncate and curiously etched out, pitted, and wrinkled, the grooving extending down the outer side; oral spines, 8 or 9. R=60 mm., r=31 mm., R=nearly 2 r.

Description.—Abactinal plates lower than in *C. clarki*, with broader tabula in proportion to height, and with more numerous granules, especially on central part of tabulum. The larger radial plates have 15 to 22 peripheral, flattened granules, which overhang the edge of tabulum and have their distal margin square-cut or slightly rounded, or at the corners of the plate conforming to the hexagonal form of the crown. The central granules, 10 to 18 on the larger plates, are circular, flattened, and slightly spaced, but nearly uniform in size and not unequal as in *clarki* nor often markedly smaller than the peripheral. Many of the plates have a two-jawed, slightly spatulate, slender pedicellaria shaped much as in *C. clarki*, but smaller. The median radial plates are the largest, the tabulum being about one-third to three-fourths as high as wide, occasionally slightly more on a small radial plate. The plates decrease in size very gradually toward the small interradial areas, which are paved with small squarish or roundish plates separated by narrow, shallow channels. Pedicellariae are scattered also over the interradial areas. The plates of center of disk are smaller than those of radial area, less regular, and a trifle lower.

The abactinal plates have short lobes, in form much like those of *C. japonicus.* They are very short, broad, rounded, or truncate, and often irregular or unsymmetrical in position, especially on the distal and lateral portions of the papular areas. The plates are wholly different in form from those of *C. clarki*, which have the lobes bent downward so that the center of plate is hollowed out. (See Fisher, 1911*d*, pl. 59, figs. 6, 6*a*.) Papulae distributed over center of disk and very broad radial areas.

Marginal plates small, as in *C. clarki*, forming a thin rounded margin to disk. Superomarginals 18, longer than wide up to the ninth or tenth, then rather rapidly widening, the fifteenth, sixteenth, and seventeenth being the widest, and of these the sixteenth is slightly the largest and is the widest of all the superomarginals. While the other plates are closely granulate, these have a large central bare area (the thirteenth and fourteenth, a smaller) and appear swollen. This is very much as in *C. clarki*, except that in *smithi* the distal superomarginals do not touch medially, while they do in *clarki*. Terminal plate broader than long, ovoid, almost globose with a semicircular terminal series of globose granules, and several tubercular spinelets beneath them.

Inferomarginals very similar to superomarginals, the distal 6 or 7 with a central bare space increasing in size distad. The first 6 are slightly longer than wide; thence the length gradually diminishes until the distal plates are wider than long, but not wider than the proximal plates as in the case of the superomarginals.

Actinal intermediate plates numerous, flat, 4-sided, not very regular, in 12 or 13 chevrons (each, except sometimes the first, with an odd interradial plate at the apex), the plates decreasing in size toward the margin and reaching to within 4 inferomarginals of the terminal plate. Granules coarse, well spaced, subspherical or in the case of the peripheral flattened on the outer side and appressed to peripheral granules of neighboring plates. One interradius has a single spatulate pedicellaria.

Adambulacral plates at first a little longer than wide, then a trifle wider than long. Furrow margin nearly straight. Furrow spines 5, sometimes 4, equal, about as long as width of plate, compressed or prismatic, truncate or round tipped often with a pit, notch, or groove at the tip, the latter rarely running down the outer (upper) side of spine. The spines vary in shape within the same series, being triangular or square or elliptical in section, with all the intermediate variations. Just back of the furrow series is a series of 3 coarser, usually four-sided spines, slightly shorter than furrow series and occupying the full length of plate. The tip is curiously etched out by grooves which may run part way or all the way down the outer face of the tubercle. Scarcely 2 are alike. The spines increase in thickness toward the outer part of furrow, sometimes flaring widely at the tip, and finally 1 increases greatly in size over the rest and becomes a stout conical or clavate tubercle without a trace of the curious wrinkling. The form of these subambulacral spines is difficult to describe, as it varies. They have the appearance of being eaten very unevenly on the outer side by acid. The outer end of the plate is occupied by 4 to 10 prismatic, irregular granules in 1 series on the first few plates, 2 on the rest, or without serial arrangement. I find just 1 plate with a 2-jawed spatulate pedicellaria.

Mouth plates with slightly curved furrow margin bearing 8 or 9 spines variable in form, but similar to the adambulacral spines. They increase in size and become more compressed and broader toward the mouth angle; and the tip, which is usually blunt or truncate, is irregularly pitted and etched out, as described above. Parallel to this is a series of 5 or 6 suboral spines similar to, but larger than, the homologous subambulacral. Six to 12 coarse prismatic granules occur on the outer part of the plate, mostly on the sutural and lateral margins.

Madreporic body fairly large, with fine meandering striae, situated one-third of r from the enlarged "central" or apical plate.

The anatomy could not be worked out beyond the most salient features. Gonads single, on either side of the interbrachial septum, situated about 6 mm. from marginal plates and 4 or 5 from the septum. Polian vesicle long, reaching nearly to marginal plates. No subambulacral ossicles or rudiments.

Young.—A specimen from station 5348 with R 23 mm. and r 15 mm. seems to belong to this species. It differs from the adult in much the same way that a small specimen of *clarki* differs from the large type.

The most conspicuous difference of this young specimen (the gonads are very small) is to be found in the marginal plates. These are relatively heavier, and normal for the genus, and all of them have a dorsal bare spot which increases in size distad until it occupies nearly the entire surface of the plate. The proximal plates are a trifle wider than long, the width increasing gradually up to the eighth, the last 2 plates being smaller. At the same time the length of the plates gradually decreases so that these distal plates are more than twice as wide as long and agree with those of the adult in being larger than the proximal. The abactinal plates have the same character as in the adult but have only 4 or 5 central granules, decreasing to 2 or 3 on the smaller plates, and the 10 or 12 marginal granules are slightly larger than the central. The adambulacral spines lack the pits and furrows characteristic of the adult, but the number of the spines is the same. The tips are smoothly rounded or truncate. Oral spines 10. This specimen differs from the immature *C. clarki* (from station 4407, near Santa Catalina Island, California, 334 to 600 fathoms) in having lower tabula to the abactinal plates, relatively slightly larger crowns, a differently formed base (as in adults), smaller pedicellariae, wider superomarginal plates distally (in young *clarki* they are not wider than the proximal plates); shorter and heavier furrow spines, more crowded adambulacral aramature generally, and no pedicellariae, such as are frequently present in *clarki*.

Type.—Cat. No. 30551, U.S.N.M.

Type-locality.—Station 5201, Sogod Bay, southern Leyte Island, 554 fathoms, gray sand, mud, bottom temperature 52.8° F.; 1 specimen.

Distribution.—Palawan Passage to Leyte, Philippine Islands, 375 to 554 fathoms, gray sand and mud. Temperature range 52.8° to 54.4° F.

Specimens examined.—The type and a specimen from station 5318, Palawan Passage (lat. 10° 57′ 45″ N.; long. 118° 38′ 15″ E.); 375 fathoms, coral sand; bottom temperature, 56.4° F.

Remarks.—The only species of the Indian region with which this may be confused is *Pentagonaster cuenoti* Koehler from off southern India, 1,006 fathoms. The resemblance is not close, however, and it is probable that *cuenoti* belongs to a different section of the genus. Koehler does not state that the radial plates are tabulate, and they do not appear so in the figure. The plates are small, and each is covered by 5 to 7 small roundish granules without order. In the radial regions there are a large number of papular pores irregularly disposed. Likewise the marginal plates do not increase in size distad, and there are 7 furrow spines. In "*Pentagonaster*" *pulvinus* Alcock the plates are close set, and no papulae were visible even after the granules were removed. Although Alcock states that the angular granules show a paxilliform arrangement, I am uncertain whether the plates are elevated. I suppose not, as he says the species is related to *Pentagonaster mirabilis* (which is *P. placenta*, probably referable to my *Sphaeriodiscus*). *Pentagonaster* (*Philonaster*) *mortenseni* Koehler seems to be closely related to *Ceramaster arcticus* (Verrill) and differs from *smithi* in having much smaller, higher paxilliform plates with usually 1 or 2 central granules and 6 or 8 peripheral ones very regularly arranged. This arrangement is found on the smaller plates near the margin, the size only changing.

This species is named for Dr. Hugh M. Smith.

Genus NYMPHASTER Sladen.

Nymphaster SLADEN, 1885, p. 612; 1889, p. 294. Type, *N. protentus* Sladen, by designation, Fisher, 1917.

Dorigona PERRIER (not Gray), 1885, p. 39; 1894, p. 365.—KOEHLER, 1909, p. 54; 1910*a*, p. 60.

Diagnosis.—Goniasteridae with long rays, composed dorsally of the superomarginals only; with low, not markedly tabulate, granulate, abactinal plates; actinal interradial areas large, granulate; adambulacral plates with the furrow margin strongly angular, at least on plates of distal half of ray, the angular furrow series separating consecutive pairs of tube feet; pedicellariae spatulate, entrenched, or composed of more or less modified granules; no superambulacral ossicles; no internal supplementary abactinal ossicles; gonads in a single tuft on either side of the membranous interbrachial septum.

Remarks.—This genus differs from *Rosaster* and *Mediaster* in lacking internal abactinal ossicles connecting the plates of the papular areas, and in having the gonads in a single tuft, not serially arranged. It differs further in the form of the adambulacral plates and armature. *Mediaster* has superambulacral ossicles, not found in *Nymphaster*. *Nymphaster* differs from *Ceramaster* in having single gonads on either side of each interbrachial septum, angular adambulacral plates, long rays, and in having low, not tabulate abactinal plates.

In his diagnosis of the genus, Sladen did not mention any specific names, so that, under existing rules of nomenclature, the genus should date from the *Challenger* report of 1889. Here no type is indicated, and none has been designated. The following species are described: *symbolicus*, *bipunctus*, *protentus*, *albidus*, *basilicus*. In 1899 Verrill set aside *symbolicus* and *bipunctus* under the name *Nereidaster*. This group, which is more nearly related to *Mediaster* than to *Nymphaster*, falls within the genus *Rosaster* Perrier, 1894. The type of *Nymphaster* must be chosen from the three remaining species, and for this purpose *Nymphaster protentus* is best adapted.

Koehler (1910*a*, p. 60) has proposed to limit the name *Nymphaster* "to the forms in which the superomarginals are separated by a series of abactinal plates and to reserve the name of *Dorigona* for those in which the marginal plates are contiguous." This course is not possible, because Verrill has already limited *Nymphaster* to the genus which Koehler, following Perrier, calls "*Dorigona*." The genus which Koehler calls "*Nymphaster*" is that previously named *Nereidaster* (type *N. symbolicus*) by Verrill, which in turn is congeneric with the earlier *Rosaster* of Perrier (type *Pentagonaster alexandri*).

It is greatly to be regretted that Koehler has lent the weight of his authority to such an obvious misuse of a name as that of *Dorigona.* There is no possible excuse for the use of this name for *Nymphaster.*

In assuming to call this genus *Dorigona* (Gray, 1866, p. 7) it is also necessary to assume that Gray's genus included originally one or more true *Nymphaster*, which, as is well known, it did not. The type of the genus is *Dorigona reevesii*, the same species as *Ogmaster capella* von Martens (1865). *Dorigona* is therefore synonymous with *Ogmaster* and its status in nomenclature is fixed for all time. It is true that Gray mentioned another species, *Astrogonium longimanum* Möbius, but this is not congeneric with *Dorigona reevesii*, and is given a distinctly secondary place by Gray. Sladen made it the type of his new genus *Iconaster*, in 1889. It will be noted that no true *Nymphaster* is mentioned, and, in fact, this group was not discovered until many years afterward, during the expeditions of the *Challenger* and the *Blake.*

The following is a short history of the name in Perrier's writings. In 1875 in the "Revision," p. 228, *Dorigona* is used as a subgenus exactly in the sense that Gray uses the name in his "Synopsis" of 1866, with the exception that *Ogmaster capella* is called *Pentagonaster mülleri* instead of *Dorigona reevesii.* *Astrogonium longimanum* is listed under the name *Pentagonaster longimanus.* In 1884 *Pentagonaster ternalis*, *P. subspinosus*, and *P. arenatus* are described from the *Blake* collections, but no mention is made of *Dorigona.* But in the following year[1] the last, and a new species, *prehensilis*, are placed in the "Genus Dorigona Gray" without comment. In 1894, p. 365, we find *Dorigona* again used in the sense of *Nymphaster.* It is interesting to note that Perrier in the synonymy omits the original citation, his first reference being to the "Revision" of 1875. He then gives a generic description which obviously applies to *Nymphaster* and has nothing to do with the genus *Dorigona* of Gray, let alone the fact that none of Gray's species are included. Perrier himself does not believe that *Ogmaster capella* is congeneric with *Dorigona ternalis*, yet by what reasoning *ternalis* is placed in a genus of which *Ogmaster capella* is the type, it is beyond me to discover. His only apology is an observation on page 367:

> The genus *Dorigona*, in the sense in which we have just limited it, corresponds to the genus *Nymphaster* of M. P. Sladen, who gave absolutely without necessity a new name to a generic division long since indicated and of which the limits demanded revision in relation to recently discovered genera.

---

[1] Note prelim. sur les échinod. dragués par le *Travailleur* et le *Talisman*, Ann. sci. nat., 1885, p. 39.

The gist of this quotation is that Sladen did not adopt Perrier's incorrect use of *Dorigona*. With such reasoning it is no great wonder that the nomenclature of the Asteroidea became tangled.

KEY TO THE SPECIES OF NYMPHASTER HEREIN DESCRIBED.

*a*¹. Marginal mouth spines (bordering on mouth of ambulacral furrow) 6 or 7, exceptionally 8 (if 8, then rays not conspicuously slender, but if measured at proximal suture of the first pair of superomarginals which meet medially, equaling length of first 3½ to 4½ superomarginals measured on ambitus); some of the radial plates wider than long; mouth plates small, and rays stout, the inferomarginals extending laterally beyond superomarginals.

- *b*¹. Mouth plates nearly or quite inclosed by the first pair of adambulacrals; numerous subambulacral spines; abactinal granules mucronate. *mucronatus*, p. 269.
- *b*². Mouth plates not inclosed; subambulacral spines few or none (granules only); abactinal granules at best only incipiently mucronate, and these few in number.
  - *c*¹. Five longitudinal series of abactinal radial plates with the distal as well as proximal plates obviously wider than long; no marginal or abactinal pedicellariae; inferomarginals and superomarginals wider, the latter on rays, the former on disk; width of ray as measured in *a*¹, equaling first 4 or 5 superomarginals------------*euryplax*, p. 264.
  - *c*². Radial plates not so obviously wider than long, the difference showing on the proximal plates of the radial areas rather than on the distal; numerous abactinal and a few marginal pedicellariae; superomarginals narrower on ray and inferomarginals narrower on disk; ray measured as in *a*¹, equaling first 3½ superomarginals--*dyscritus*, p. 266.

*a*². Marginal mouth spines 8 to 15 (if the lowest number, or exceptionally less, then rays also very slender throughout).

- *b*¹. Abactinal radial plates conspicuously wider than long (much as in *mucronatus*); rays very slender--------------------------*leptodomus*, p. 272.
- *b*². Abactinal radial plates roundish or hexagonal, not conspicuously broader than long.
  - *c*¹. Second superomarginals meeting in median line across ray (4 superomarginals in each interbrachium); inferomarginals of ray very narrow and long, the length at middle of ray exceeding the height (or thickness) of lateral face of ray; rays slender and delicate; oral spines, 10 or 9------------------------------------*atopus*, p. 285.
  - *c*². Fourth, fifth, and sixth superomarginals meeting in median line across ray (sometimes third in young specimens), and therefore 6 to 12 superomarginals to each interbrachium); length of inferomarginals at middle of ray equal to or less than height of lateral face of ray.
    - *d*¹. Ray broader at base, measured as in *a*¹ equaling first 4½ superomarginals; superomarginals very broad, not tumid; oral spines, 10 to 12; furrow spines 10; inferomarginal plates of interbrachia extending laterally beyond superomarginals-----------*moluccanus*, p. 274.
    - *d*². Ray narrower at base, measured as in *a*¹, equaling first 3 to 4 superomarginals; if approaching *d*¹, then superomarginals tumid; in interbrachia superomarginal plates extending laterally beyond inferomarginals.

e^1. Marginal plates individually tumid; no adambulacral pedicellariae; mouth spines 9 or 10; furrow spines 9 to 11 at middle of ray____*arthrocnemis*, p. 277.

e^2. Marginal plates not individually tumid; adambulacral pedicellariae; furrow spines at middle of ray more than 11.

  f^1. Dorsolateral angle of ray about 90°, square cut; dorsal surface plane; marginal granulation closer; sixth and sometimes fifth superomarginal longer than width of its dorsal surface; 10 inferomarginals corresponding to about 16 adambulacrals; mouth spines 9 to 11___________________________*meseres*, p. 280.

  f^2. Dorsolateral angle of ray more rounded, the dorsal surface being convex; marginal granules more spaced; ninth or tenth superomarginal longer than width of its dorsal surface; 10 inferomarginals corresponding to 13 or 14 adambulacrals; mouth spines 12 to 15____________________________*habrotatus*, p. 282.

NYMPHASTER EURYPLAX Fisher.

Plate 63, fig. 3; plate 72, fig. 2; plate 92, figs. 6, 6*a*.

Nymphaster euryplax Fisher, 1913*a*, p. 634.

Diagnosis.—General form, similar to that of *N. diomedeae* Ludwig and *N. ternalis* (Perrier), but superomarginals with plane abactinal surface, not tumid; rays broad at base and actinal surface conspicuously wider than abactinal, the edges between the 4 faces of the ray being abruptly angular, disk arcuately pentagonal, gradually merging into rays at corners; extreme width of ray, measured at proximal suture of the first pair of superomarginals which meet medially, equaling length of first 4 or 5 superomarginals, measured on ambitus; inferomarginals broad; rays not sunken along median radial line; inferomarginals broader than superomarginals on disk, but narrower on ray; radial and adradial abactinal plates broader than long, hexagonal, elliptical, and lozenge-shape; adambulacral plates with very strong furrow angle and 9 or 10 furrow spines, the apices of the angles of opposite plates meeting in middle of furrow and segregating consecutive pairs of tube feet beyond proximal fourth of furrow; mouth plates with 6 to 8 marginal spines; no pedicellariae except rarely on the first few adambulacral plates. R=slightly over 95 mm. (ray broken), r=27 mm. R=a little over 4 r.

Description.—Abactinal area arcuately pentagonal in shape; petaloid papular areas broad, the extreme width comprising about 10 to 12 longitudinal series of plates; plates rather compactly placed, those of radial and 2 adradial series much wider than long, hexagonal, lozenge-shaped or rather pointed ellipitical, the others of the papular areas roundish or subhexagonal, often slightly wider than long. A large radial plate has 5 to 12 central, low, subspherical uncrowded granules and upward of 20 squarish depressed peripheral granules a trifle smaller. On the lateral parts of papular areas the central granules become more convex with a short incipient mucronate tip; interradial granules flat-topped. No pedicellariae.

Inferomarginal plates broad, wider than high, with an abrupt nearly right angle between the 2 facets of the plate; plates increasing in width up to the fifth, which at its distal end meets its fellow of the other side of ray in the median line; thence the plates decrease in width. The abactinal surface of ray is nearly plane but in interbrachium the plates form a slight bevel. Width of dorsal surface equals length of the seventh or eighth to fifteenth, varying on different rays. Covering of plates consists of depressed, subcircular, convex granules, slightly spaced, and similar in size to adjacent abactinal granules, but decreasing very gradually in size toward end of ray.

Inferomarginals extending laterally beyond superomarginals except on attenuate terminal portion of ray, the sutural line between the 2 series being at the bottom of a shallow sulcus of which the lateral faces of the 2 series form the sides. Ventral face of plates broad in interbrachia—about 3 times height—but they rapidly become narrower, and at middle of ray the ventral facet changes from square to slightly longer than wide, 10 inferomarginals equaling 18 adambulacral plates; the plates are not conspicuously long as in some species. Granules small, depressed, hemispherical, except 2 or 3 peripheral series which are acorn-shaped with a mucronate tip. In interbrachium in the angle between the 2 facets the granules are much enlarged, subtubercular, acorn-shaped, with a sharp tip.

Actinal intermediate plates extend to fifth inferomarginal and are arranged in series parallel to furrow; each series with an odd interradial plate, and there are 5 of these plates between mouth plates and margin. Granules low, acorn-shaped, slightly spaced, nearly uniform in size. No pedicellariae.

First 2 or 3 adambulacral plates with 5 or 6 furrow spines, blunt, nearly equal, slightly compressed, then the plates gradually attain first a convex then a strongly angular margin, and the furrow spines increase to 9 (less often 10), the 3 to 5 median, nearest apex of angle being more slightly built, compressed, with edge to furrow, the 2 to 3 at either end of series being stouter, sublanceolate, blunt, with flat side to furrow. Subambulacral granules 8 to 16, in 2 or 3 series on outer part of ray, but not so regularly arranged, as a rule, proximally. The outer granules are subconical or acorn-shaped, but a series of 2, 3 or even more back of the furrow spines are longer, slightly flattened, and rather tubercular in form. It seems to be from these spines that the extra furrow spines are recruited, the original furrow spines remaining at the center of series. A very few pedicellariae with 2 curved spiniform jaws are present at the base of the series and are not of regular occurrence.

Mouth plates small with short furrow margin. Marginal spines 6 to 8, usually 7 or 6, and similar to adambulacral furrow spines, only a little heavier. Suboral spines about 10-12 in 2 series, along the 2 remaining edges of the triangular plates, and granuliform near the outer end of plate. The spines are graduated regularly in size away from the furrow margin.

Madreporic body small, irregularly hexagonal, about one-fourth r from center.

Type.—Cat. No. 30542, U.S.N.M.

Type-locality.—Station 5516, Mindanao Sea, off Point Tagolo, Mindanao, 175 fathoms, globigerina; 1 specimen.

Remarks.—This species, which in form resembles *N. diomedeae* Ludwig from the Gulf of Panama region, differs in having more numerous adambulacral furrow spines, marginal plates which are not tumid, inferomarginals extending laterally beyond superomarginals, enlarged subambulacral granules, and a finer actinal granulation. The abactinal plates of the papular area seem to be broader and lower, and lack pedicellariae. *N. euryplax* closely resembles *N. belli* (Koehler) from 250 fathoms off the Andaman Islands. It agrees in having the radial and adradial abactinal plates much broader than long, in having the ray broad at the base, with the fifth superomarginal conspicuously enlarged and in contact medially, and in the general absence of abactinal pedicellariae, but differs in having the inferomarginals extending laterally beyong the superomarginals, so that the actinal surface is wider than the abactinal. This character also separates *N. euryplax* from *N. ludwigi* Koehler and the species identified by Koehler (1909, p. 54) as *N. ternalis* (Perrier), neither of which, in addition, have the wide abactinal plates. Further, *N. euryplax* differs from *belli* in having longer, stouter, rays; the 2 or 3 series of abactinal plates parallel to the adradial are not so wide in proportion to length—are nearly round and have more numerous granules; the madreporic body is surrounded by 6 plates, not 4; the first row of suboral granules is enlarged into spines; the furrow spines are 9 or 10 at the middle of ray (Koehler gives 7 or 8 for *belli*, but possibly he referred only to the proximal plates, where in *euryplax* there are at first 5 or 6, then 7 or 8, and finally a maximum of 9 or 10).

NYMPHASTER DYSCRITUS Fisher.

Plate 62, fig. 2; plate 65, fig. 3; plate 92, figs. 5, 5*a*–*b*.

Nymphaster dyscritus FISHER, 1913*a*, p. 635.

Diagnosis.—Differing from *N. euryplax* in having less obviously widened abactinal radial plates, slightly narrower superomarginals, the sixth being as long as or longer than wide (eighth to sixteenth in *euryplax*) when viewed directly from above; numerous abactinal pedicellariae, a few superomarginal, inferomarginal, and actinal intermediate pedicellariae; narrower inferomarginal plates in the interbrachia: slightly coarser actinal intermediate granules. Rays at inner end of first pair of superomarginals which meet medially as wide as length of first 3.5 superomarginals measured on ambitus; interbrachia arcuate; dorsal surface of ray nearly plane with abrupt angles on the margin of disk and ray. R=probably nearly 4 r; r=23 mm.; breadth of ray at midinterbrachium, 26 mm.

Description.—General appearance is much like that of *N. moluccanus*, and also similar to Koehler's *N. ternalis* from the Indian region. The proximal radial and 2 adradial series of marginal plates are wider than long, but the width gradually decreases, so that on the distal half of the papular areas the plates are only slightly wider than long. The granules are roundish, flat-topped, and the central are in 2 or 3 transverse rows proximally and 2 distally (in *euryplax* often in only 1 row distally). The largest radial plates have 8 to 11 central granules and about 15 peripheral. The small 2-jawed pedicellariae have a broad base and a narrow spatulate extremity and are about 1.5 as high as width at base. Papular areas comprising 7 to 9 longitudinal series of plates.

Rays broken. Marginal plates with an abrupt angle at edge of ray. Superomarginals with fifth or sixth plates meeting medially, the interbrachial plates only a little wider than long, as seen from above, the sixth being as long as or a little longer than wide, the subsequent ones longer than wide. In interbrachium, height of plate about one-half the width. A well-marked sulcus all along side of ray. Granules small, circular, truncate, spaced, becoming hemispherical on the lateral face. A small, slender pedicellaria on most of the interbrachial plates has 2 compressed jaws, so that when seen from the side it is ovate.

Inferomarginals narrower than in *euryplax*, slightly arched, the fourth as wide as long, as seen from below. Twenty or 21 adambulacrals corresponding to 10 inferomarginals (18 in *euryplax*). Inferomarginals extending laterally beyond superomarginals, very slightly on ray, scarcely at all in midinterbrachium. The lateral angle, except far long ray, is less than a right angle. Pedicellariae similar to those of superomarginals, as are also the granules, these becoming coarser on the exposed angle of ray. Granules of actinal surface are hemispherical as on the lateral face.

Actinal intermediate plates in 5 chevrons, with coarse spaced hemispherical granules, fewer and larger than in *euryplax*, and larger in center of plate, as in *mucronatus*. One or two slender pedicellariae present at base of ray.

Adambulacral plates similar to those of *euryplax*, the apophysis appearing on the first plate, but not becoming conspicuous for 5 or 6 more plates. The first plate has 5 or 6 furrow spines, which increase to 10, the laterals being broader than the 2 or 3 mesial spines, which are compressed to an even thickness, but are slightly tapering and round-tipped when seen from the side, as indeed are the laterals. Subambulacral granules 10 to 14, in about three series, the inner slightly longer than the outer. The first few plates have a pedicellaria, with two or three coarse tapering, slightly curved, bluntly pointed spiniform jaws.

Mouth plates small, with 7, rarely 8, marginal prismatic spines, and about 8 pointed tubercular prismatic or 4-sided oral spines in a single row on inner end of plate, becoming 2 rows of granules on outer end.

Madreporic body pentagonal, surrounded by 5 plates, situated one-quarter r from center.

Type.—Cat. No. 30543, U.S.N.M.

Type-locality.—Station 5536, between Negros and Siquijor Islands, Philippine Islands, 279 fathoms, green mud, bottom temperature 53.5° F.; 1 specimen.

Distribution.—Mindanao Sea, between Negros, Siquijor, and Mindanao.

Specimens examined.—The type and a young example from station 5541, off Point Tagolo, northern Mindanao, 219 fathoms, fine sand, broken shells, bottom temperature 53.5° F.

Remarks.—It is not possible with the material at my disposal to decide whether this is a distinct species or a variety of *N. euryplax*. Although *N. euryplax*, *N. mucronatus*, and *N. dyscritus* appear different enough, yet each is represented by but a simple adult specimen. The course taken seems best even if it is later established that they are 3 phases of one species. The characters used to discriminate them are the same that have been employed in separating other forms represented by several examples. The range of variation in *Nymphaster* is not yet well understood.

N. dyscritus differs from *N. ternalis* Perrier in having less tumid marginal plates, smaller abactinal radial plates, a sharper, more abrupt angle to margin of ray, longer superomarginals in proportion to their width (on ray), and in having the marginal apophysis on all the adambulacral plates (although not conspicuous on the first half dozen). *N. dyscritus* greatly resembles *N. ternalis* of Koehler (but not of Perrier) from the Indian region, and I shall not be surprised if they ultimately turn out to be races of the same species. Koehler's species has more regularly hexagonal abactinal plates, 8 adambulacral furrow spines (maximum?), more numerous adambulacral pedicellariae (easily a variable character), 8 or 9 mouth spines, and the apophysis commences between the third or fourth and fifteenth adambulacral plate, varying on different specimens. These differences are not very great. *N. mucronatus* differs in the form of its peculiar granules as well as in having wider plates, no abactinal or marginal pedicellariae, conspicuous subambulacral spines, smaller mouth plates inclosed by the first adambulacrals, and more flaring sides to the rays. *N. leptodomus* has conspicuously narrower rays, less massive marginals, and a generally more delicate habit. *N. moluccanus* differs in having more symmetrical hexagonal abactinal radial plates, wider superomarginals, no abactinal or marginal pedicellariae, 10 or 12 mouth spines, more numerous and compact subambulacral granules, and more uniform actinal intermediate granules.

Nymphaster gardineri (Bell)[1] from Saya de Malha Bank, western Indian Ocean, 125 fathoms, is perhaps related to this species. I have examined the type in the British Museum, but, of course, was unable to compare it directly with *dyscritus*. It resembles *dyscritus* in general form and, like it, has few mouth spines (only 5 or 6 in the marginal series), but differs in having the superomarginals of disk and ray up to the seventh or eighth beveled in such a way that they slope off from the median line of the proximal part of ray, as in *habrotatus*. The dorsal edge of disk and ray is rounded, but beyond the eighth superomarginal the ray becomes squarish in section. Furrow spines 8 (6 on proximal plates) the apophysis of the plate not well marked until the ray proper commences. On the surface of the adambulacrals are 4 spines slightly shorter than the furrow spines, and external to these, about 2 rows of granules with 3 in each row, or an ellipse of 6. The inferomarginals are wider than long up to the seventh (or sixth), then a plate is square (seventh or eighth), beyond which the actinal face of the plates is much longer than wide. In 10 inferomarginals, beginning with the sixth, there are 16 to 18 adambulacral plates. No well-marked subambulacral spine on outer part of ray. The median row of paxillae "transversely" hexagonal, the granules being smooth and even. The sixth superomarginal meets its fellow across ray, while the fifth is the widest.

N. gardineri falls under a^1 of the key, but does not have the broadened radial plates of *euryplax* nor the mucronate granules of *mucronatus.*

NYMPHASTER MUCRONATUS Fisher.

Plate 63, figs. 1, 2; plate 68, fig. 5; plate 69, fig. 6; plate 92, figs. 1, 1*a*.

Nymphaster mucronatus Fisher, 1913*a*, p. 636.

Diagnosis.—Very similar to *N. euryplax* in general form and in having the radial plates wider than long, but differing in having much less compact radial plates with fewer and mucronate granules;

---

[1] *Iconaster gardineri* Bell, Trans. Linn. Soc. Lond., 1909–10, vol. 13, Zool., p. 22.

larger madreporic body; narrower inferomarginals; coarser, and more tuberculate, sometimes mucronate, unequal, actinal intermediate granules; smaller mouth plates, with the first adambulacrals nearly or quite meeting behind them; many of the subambulacral spines of conspicuous size, and graduated into the tubercular granules of the actinal intermediate plates. Rays broad at base, the width at inner end of the first 2 superomarginals which meet medially equaling first 4 superomarginals measured on ambitus; interbrachia arcuate; inferomarginals defining contour of ray; dorsal surface of ray nearly plane; normal marginal plates not tumid, though inferomarginals with slightly arched ventral surface; adambulacral furrow spines 4 or 5 on first few plates, these gradually increasing to 9 or 10; oral spines 6 or 7. R=101 mm., r=30 mm., R=3.4 r; breadth of ray at midinterbrachium, 34 mm.

Description.—Abactinal plates small, the radial being elliptical and much wider than long; the median radial plates with 1 or sometimes 2 transverse rows of subglobular granules (4 to 8 in number), surrounded by a not very regular peripheral series of about 15 to 18. Most of the granules of these as well as of other abactinal plates have a peculiar form; it is subglobular with often 4 or 5 faces, slightly broader at tip than base, and from the middle arises a slender, sharp spine or mucro, often half as long as the granule, or rarely longer. Many granules do not have the mucronate tip, while in others there is a slight indication of it. Some of the radial granules of N. *euryplax* have a rudimentary mucronate tip, and the plates are larger and more compactly placed. Papular areas broad, comprising about 13 longitudinal series, the interradial areas, correspondingly small and with about 5 chevrons of 4-sided plates. Abactinal area within the marginal plates stellato-pentagonal. No abactinal pedicellariae.

Superomarginals 29, massive, the lateral face visible from above, and the rounded angle between the 2 facets of the plate more than a right angle. The plates encroach conspicuously upon the abactinal area and are slightly beveled in the interbrachia. Fifth or sixth plates the largest and meeting medially; sometimes a fifth meets a sixth of the other side. Length of twenty-second plate equal to chord of width, all the others wider than long; length of seventh plate equal to width of abactinal surface; the fifth and sixth are wider than long and the first to fourth vary from a little wider than long to a little narrower, with regard to the dorsal surface. Granules slightly spaced (more so on arm than disk) similar to abactinal interradial granules, but the mucronate tip present only on lateral face of ray where the granules resemble miniature acorns. No marginal pedicellariae. Terminal plate ovoid, about as wide as long.

Inferomarginals extending laterally beyond superomarginals more than in *euryplax*, but the plates narrower actinally, the fourth being longer than wide as seen from below (eighth or ninth in *euryplax*). 10 plates near middle of ray corresponding to 16 adambulacrals (about 18 in *euryplax*). Granules slightly coarser than in *euryplax*, acorn-shaped, with short mucronate tips, and not conspicuously enlarged on ambitus as in *euryplax*.

Actinal interradial areas large; plates in 5 chevrons, rather irregular, covered with acorn-shaped, pointed granules conspicuously larger in middle of plate than on margins, and increasing in size from marginal plates toward furrow; a few are submucronate. In *euryplax* the granules are smaller, uniform in size, and less tubercular.

Adambulacrals with a slight angle on the third plate which increases gradually on each succeeding plate, becoming fairly prominent on the ninth or tenth, but not meeting across the furrow until the middle of ray. This is due, of course, partly to the furrow being more open than in some other species; the plates are not less prominent than in *euryplax*. First few plates with 4 or 5 prismatic or 4-sided spines, these gradually increasing to 9 or 10, the median being compressed, broad, and bladelike with the edge of furrow, the laterals round-tipped with flat side to furrow. Proximally the median spines are larger than the laterals, but far along the ray they decrease in size and the distal spines are conspicuously stouter and wider, though not longer. Plates are at first wider than long, then for a considerable distance about as long as wide, then longer than wide. Subambulacral spines and granules at first 7 or 8 increasing to 15 or 18, arranged in at first 3, then 3 or 4, and finally 3 series, although often a serial arrangement is hard to make out. At the base of the furrow most of the subambulacrals are thick tubercular spines of several lengths, and tubercular granules here and there at outer end of plate. Farther along, the inner row, and the median members of the second, are enlarged into stout spines, nearly or quite as long as the furrow spines, while the others grade off into the tubercular granules of the actinal area; far along ray only the row nearest furrow margin is enlarged, while the outermost granules are slightly mucronate. No adambulacral pedicellariae.

Mouth plates unusually small and narrow, the 2 first adambulacrals nearly or quite meeting at their outer ends, behind the mouth plates. Furrow spines 6 or 7, stout, prismatic. Suboral spines about 8, thick, blunt, in a single irregular series.

Madreporic body large, about twice as broad as the widest radial plate; 6 plates are immediately adjacent, while 2 others encroach upon it.

Type.—Cat. No. 30544, U.S.N.M.

Type-locality.—Station 5116, mouth of Balayan Bay, Luzon (off Verde Island Passage, north coast of Mindoro), 200 fathoms, bottom temperature, 50.2° F.

Remarks.—Although this species resembles *N. euryplax* in many ways, it presents numerous points of difference which have already been mentioned in the diagnosis and description. The most conspicuous of these are the smaller and much less compact abactinal plates with their mucronate granules, the narrower inferomarginals, coarser and unequal actinal intermediate granules, the very small mouth plates, and the enlarged subambulacral spines.

N. mucronatus differs from *N. belli*, to which the form of the radial plates would ally it, in having mucronate granules, larger madreporic body surrounded by 6 plates, inferomarginals extending laterally beyond superomarginals, larger, unequal acorn-shaped, often incipiently mucronate, actinal intermediate granules, smaller mouth plates, and numerous stout subambulacral spines.

NYMPHASTER LEPTODOMUS Fisher.

Plate 66, fig. 1; plate 67, fig. 1; plate 68, fig. 3; plate 69, fig. 3; plate 92, figs. 2, 2*a*–*b*.

Nymphaster leptodomus FISHER, 1913*a*, p. 637.

Diagnosis.—In the form of the abactinal plates resembling *N. mucronatus*, but differing in having longer, slenderer rays, narrower superomarginals, inferomarginals extending little or not at all beyond superomarginals, subspherical, depressed, sometimes truncate abactinal granules, abactinal, spatulate pedicellariae, larger mouth plates, 8 to 10 oral spines, adambulacral pedicellariae, and no conspicuously enlarged subambulacral spines. Ray very slender, varying from plane to convex above, the width at inner end of the first pair of superomarginals which meet medially equal to length of first 3 superomarginals measured along side; adambulacral furrow spines proximally 6, distally 10 or 11. R=70 mm., r=17.5 mm., R=4 r; breadth of ray at midinterbrachium, 20 mm.

Description.—Abactinal area arcuate-pentagonal to stellato-pentagonal. Radial plates broader than long, at least for the 5 median rows, the midradial the broadest, elliptical to broadly hexagonal or lozenge-shaped, with a variable number (usually small, 2 to 6) of spaced central granules in 1 or (proximally) 2 transverse rows, and 15 to 18 slightly smaller peripheral granules. These granules are variable in form, convex, or truncate, roundish. Many of the radial plates have a narrow spatulate 2-jawed pedicellaria, the jaws, when open, reaching nearly across the plate. Papular areas broad, petaloid, comprising 9 to 11 longitudinal series of plates. Interradial areas small, with small four-sided or five-sided not very regular plates with small spaced granules. Viewed from the inner or coelomic side the abactinal plates form very regular longitudinal series, those of the median radial being conspicuously the largest. Most of the plates are provided with short lobes, but they are of irregular occurrence. On many of the median radial plates there are 6 short lobes.

Superomarginal plates narrow abactinally, the sixth meeting its fellow in the median line of ray. Interbrachial plates forming a slight to decided, narrow, bevel; fifth and sixth the largest of series; dorsal surface of first 4 plates about as wide or slightly narrower than long; fifth and sixth slightly wider than long, and then the width gradually decreases, the plates from the eighth being longer than wide. Edge of ray an abrupt, rounded, right angle, the height of plates being a little more than half the width (and on ray relatively lower than in *mucronatus*). Granules slightly spaced, subspherical, becoming low conical on the lateral face of plate. Terminal plate small, ovoid, about as wide as long, pointed proximally, and rounded distally.

Inferomarginals narrow, the second, viewed from below, as wide as long, and the succeeding ones increasingly longer than wide. On the outer half of ray the plates are extremely narrow actinally, the surface being rather evenly rounded between the inner and outer edge of the plate. Ninth to nineteenth inferomarginals (10 nearest middle of ray) corresponding to 14 adambulacrals. Granules coarser on actinal than on lateral face, subspherical to depressed acorn shape. In the interbrachia of the type-specimen some of the lateral granules are submucronate.

Actinal intermediate plates in 4 chevrons, with an odd plate in the interradius. Granules fairly coarse, spaced, the central slightly the largest, and in form depressed conical or acorn-shaped. A variety has smaller more spaced granules.

Apophysis or projecting angle appearing on the first or the second adambulacral and becoming prominent on the fifth or sixth. First and second plates with 6 furrow spines, which increase on the ray to 10 or 11, the lateral members being often granuliform, the others of the usual shape, the median compressed with edge to furrow, and the distal 3 or 4 with flat side thereto. Subambulacral granules, acorn-shaped, 6 to 12 in 2 or 3 series proximally, and 2 distally, 1 or 2 granules in the inner angle being slightly enlarged. Many of the plates as far as middle of ray have a rather conspicuous pedicellaria with 2 or 3 incurved jaws situated on the inner part of the plate.

Mouth plates with 8 to 10 marginal and about the same number of suboral spines, the former compressed, the latter more conical, and graduated in length to conical granules on the outer end of plate. The plates seem to be larger than in *mucronatus*, but as the specimens of *leptodomus* are all smaller the difference may not be reliable. The first adambulacrals do not touch behind the mouth plates.

Madreporic body variable but fairly to decidedly large, surrounded by 6, 7, or 8 plates and situated about one-third the distance from center to ambitus.

I have examined this species for rudimentary superambulacral plates, but can find none. Gonads in 1 tuft on either side of the membranous interradial septum.

Variations.—One of the specimens from the type-locality differs from the others in having a larger madreporic body, more convex rays dorsally, but as the details of structure fit this species well I have considered it an extreme variant.

Type.—Cat. No. 30545, U.S.N.M.

Type-locality.—Station 5216, between Burias and Luzon, 215 fathoms, green mud, bottom temparture 63.1° F.; 5 specimens.

Distribution.—Known only from region between Burias and Luzon.

Specimens examined.—In addition to the type, 6 from station 5388, between Burias and Luzon, 226 fathoms, soft green mud, bottom temperature 51.4° F.

Remarks.—*N. leptodomus* strongly suggests *N. mucronatus* on account of the form of the abactinal radial plates, but the rays are much narrower. The characteristic mucronate granules are absent from the abactinal plates, there are numerous abactinal pedicellariae, and the characteristic subambulacral spines of *mucronatus* are absent. From *N. belli*, *leptodomus* differs in having longer, narrower rays; numerous abactinal and adambulacral pedicellariae; narrower superomarginal plates; larger madreporite, surrounded by more than 5 plates (4 in *belli*); a maximum of 10 or 11 furrow spines.

NYMPHASTER MOLUCCANUS Fisher.

Plate 64, fig. 3; plate 65, fig. 2; plate 68, fig. 7; plate 92, figs. 3, 3*a–b*.

Nymphaster moluccanus FISHER, 1913*a*, p. 637.

Diagnosis.—Similar in general form to *N. euryplax*, but radial paxillae smaller, hexagonal, and not conspicuously widened: petaloid papular areas narrower and oral spines 10 to 12; marginal plates rather broad; ray broad at base, the width at inner end of the first pair of superomarginals which meet medially equaling length of first 4½ superomarginals measured on ambitus; adambulacral plates with strong furrow angle; minimum number of furrow spines at base of ray 8 or 7; maximum number 10 (rarely 11). R=86 mm., r=21.5 mm.; breadth of ray at midinterbrachium, 26 mm.

Description.—Abactinal area arcuately pentagonal, as in most species; the petaloid papular areas narrower than in *euryplax*, comprising 7 to 9 longitudinal series of plates, the plates themselves being smaller; triangular interradial areas large, the base comprising the 6 median interbrachial superomarginals (about 4 in *euryplax*); plates of papular areas smaller than in *euryplax*, hexagonal, a few of the proximal median radials being slightly wider than long and some of the laterals roundish. Proximal median radial plates with 8 to 10 circular depressed central granules (in 3 transverse series) and 15 or 16 slightly smaller peripheral ones. A specimen from station 5625 has 2 to 5 central and 10 to 12 peripheral on the largest radial plates. Plates low, the top of the granule being about 1.5 times its width above the integument. Interradial plates in regular chevrons pointing to center. No abactinal pedicellariae.

Superomarginal plates broad, very faintly convex, and with an abrupt rounded angle at ambitus. They form a slightly raised border to disk, and one which is a trifle beveled; fifth superomarginals the largest, meeting medially, the dimensions being shown by the figures. Granules, depressed hemispherical, slightly larger than on neighboring abactinal plates, slightly spaced, with a regular beadlike marginal series. Superomarginals 28 in cotype. Terminal plate longer than wide, the distal end broad and subtruncate, the inner half of plate tapering to a blunt point.

Inferomarginals projecting slightly beyond superomarginals in interbrachia and on base of rays, and encroaching inward toward center of disk, interradially about as much as superomarginals. Fourth plate slightly longer than width of ventral face. The length remaining the same to about the middle of ray, but the width rapidly diminishing. In *euryplax*, in which the inferomarginals are larger, the length does not exceed the width of the ventral facet until the seventh or eighth plate is reached. The 10 plates nearest middle of ray correspond to 18 or 19 adambulacrals. A shallow sulcus along the side of ray and disk, not so well marked as in *euryplax*. Granules are hemispherical, similar to those of actinal interradial areas; not tuberculate on ambitus, as in *euryplax*. No marginal pedicellariae.

Actinal intermediate plates extending to fifth inferomarginal, there being 4 or 5 chevrons in each interradial area, with an odd interradial plate at the point of each chevron. Granules hemispherical, slightly spaced or touching, and increasing slightly in size toward furrow. One or 2 small 2-jawed pedicellariae are present in 3 interradii.

First 7 or 8 adambulacrals of type with 8 (rarely 7) regular, short, blunt, 4-sided, slightly tapering furrow spines, which increase to 10 (rarely 11) on the ray. In the cotype the maximum number is 13 or 14. Angle on margin of plate first shows at fourth or fifth plate and rapidly increases in prominence, the adoral facet of the apophysis being about two-thirds the length of the aboral, which is slightly hollowed out. The tube feet may be separated by the spines, as near the mouth as the sixth or seventh plates, according to the width of furrow and position of spines. On plates with a prominent angle the median spines are the longest and slenderest, being compressed, slightly tapering and blunt, while the lateral spines are shorter, stouter, and blunter and have their broad side to furrow. Subambulacral granules 15 to 25 in 3, sometimes 4, irregular rows; outer granules hemispherical, becoming somewhat 4-sided or prismatic toward the furrow, and in the disk the innermost series is enlarged into short tubercular subprismatic spines, which decrease in length as the base of ray is approached; on the ray there are only granules. On the disk a few plates have a small pedicellaria with 3 slender curved jaws in the inner series of subambulacral spines opposite the furrow angle.

Mouth plates with 11 or 12 furrow spines (as few as 10) and 2 series of about 15 suboral spines and granules. The furrow margin, at the end of the plate, is hollowed out for the first tube foot, so that the marginal series of spines is not straight but in a compound curve. Near the inner end of the combined plates the suborals form a double series of 4 to 6 spines, each series diverging and running parallel to the furrow margin, the outer half of plate being occupied by granules.

Madreporic body rather small, surrounded by 6 or 5 plates and situated one-third the distance from center to inner edge of marginal plates.

Type.—Cat. No. 30546, U.S.N.M.

Type-locality.—Station 5622, between Gillolo and Makyan Islands, Molucca Islands, 275 fathoms, gray mud; 1 specimen.

Distribution.—Molucca Islands, 230 to 275 fathoms.

Specimens examined.—The type and a specimen from station 5625; between Gillolo and Kayoa Islands, 230 fathoms gray mud, fine sand.

Remarks.—This species differs from *N. ludwigi* (Kœhler) in having broader rays at the base which taper more abruptly; more numerous marginals in each interbrachium; wider adambulacrals with 3 or 4 rows of granules instead of 2; much more prominent apophyses proximally on the adambulacral plates; a few adambulacral and actinal intermediate but no marginal nor abactinal pedicellariae; madreporic body surrounded by 5 or 6 plates instead of 4. The marginals of *N. ternalis* Perrier are conspicuously tumid and the oral spines only 9. Perrier states that the apophysis starts at the twenty-fourth adambulacral plate, while in *moluccanus* the angle is well marked on the fifth plate and is apparent even before that. However, a specimen from the United States National Museum, taken at station 2398, referred to *N. ternalis*, has the apophysis ("*saillie* *verticale*") apparent on the third plate. This specimen has narrower rays than *moluccanus*, larger radial plates, with more numerous granules. It is probably not true *ternalis*. Among the species figured by Perrier (1894) *moluccanus* most nearly resembles in general appearance *N. arenatus*, but the marginals are not so wide in proportion to length, there being fewer in each interbrachium than in *arenatus;* oral spines more numerous (9 in *arenatus*); furrow spines more numerous (7 in *arenatus*); subambulacral granules much more numerous. The form of the radial plates will separate *moluccanus* from *belli.*

NYMPHASTER ARTHROCNEMIS Fisher.

Plate 64, fig. 1; plate 65, fig. 4; plate 68, fig. 1; plate 69, fig. 1; plate 92, figs. 9, 9*a–b*.

Nymphaster arthrocnemis FISHER, 1913*a*, p. 638.

Diagnosis.—In the form of the marginal plates resembling *N. ternalis*[1] (Perrier) but with smaller disk, longer rays, smaller radial abactinal plates, smaller papular areas; furrow angle of adambulacrals beginning with the third or fourth instead of the twenty-fourth plate; no adambulacral and marginal pedicellariae. Marginal plates tumid, the median line of ray depressed below the lateral angle of superomarginals; ray rather slender from the base, the width at inner end of first pair of superomarginals which meet medially equaling length of first 4 superomarginals (or a trifle less); radial plates hexagonal; mouth plates with 9 marginal spines and adambulacrals with at first 7 furrow spines and at middle of ray 9 to 11, usually 10; actinal granulation coarse; no pedicellariae except on abactinal plates. R=85+mm., r=21 mm., R=over 4 r (small portion of tip of ray broken); breadth of ray at midinterbrachium, 24 mm.

Description.—Abactinal area, inside the marginal plates, nearly pentagonal and slightly produced at corners. Abactinal plates very regularly arranged, the papular areas comprising 6 or 7 rows of roundish hexagonal plates and the triangular interradial areas about 7 chevrons of squarish or polygonal ones; or parallel with the median radial series are on either side about 9 series, of which usually 3 belong to the papular area; basal or interradial plates conspicuous, slightly larger than madreporic body, and containing about 36 granules. The larger median radial plates have 10 to 12 central and about 12 to 15 peripheral, subcircular (sometimes subpolygonal), flat-topped or slightly convex granules. The adradial plates have commonly 5 to 10 central granules. These granules are not crowded, and a slight space occurs between the central group and the peripheral series. The interradial are involved in a thin membrane. The entire granulation of this species is coarser than in *euryplax* and *moluccanus*. A few plates of the papular areas have a small pedicellaria with 2 broadly spatulate, almost truncate jaws.

---

[1] Perrier, 1884, pl. 10, fig. 1.

Superomarginals 33+, tumid, with an oblique abactinal surface on disk, and a low lateral face; but beyond the fifth, which meets its fellow medially, the dorsal surface slopes inward toward the suture between the 2 opposite series and the lateral face is about half as high as width of abactinal. The angle between the 2 facets is less than a right angle, and the edge is slightly tumid and evenly rounded. Also on the side of the ray the suture between the 2 series is in the bottom of a broad trough, the sloping sides of which are formed by the lateral facets of the 2 series. The superomarginals on disk extend laterally slightly beyond inferomarginals, and the dorsal surface of the plates is wider than long up to the ninth plate, on which the 2 dimensions are nearly equal; thence the width decreases faster than the length. Granulation coarse, spaced, and similar to that of abactinal plates, increasing slightly in size on the outer exposed edge of the ray. On a single plate, close to the abactinal plates, is a small pedicellaria, but these are not a regular occurrence on the superomarginals. The fourth and fifth plates are the largest.

Inferomarginals lower and narrower than superomarginals, and tumid, the first three being slightly wider than long, the fourth about as long as the width of actinal surface and from here on the width narrows rapidly. (In *N. ternalis* the eleventh plate is longer than wide, in *arthrocnemis* it is the seventh if the chord of the extreme width is taken and the fifth if the width of the actinal face is considered.) The 10 inferomarginals nearest middle of ray correspond to about 14 adambulacrals (18 or 19 in *moluccanus*). Granules similar to those of superomarginals, but a trifle larger on ventral surface. All the marginal sutures are deeper and wider than usual in this genus and probably act as fascioles.

Actinal intermediate plates *slightly convex*, in 4 chevrons and with three plates interradially next to margin, representing the fifth chevron. The plates of the first chevron reach to the fourth inferomarginal. The plates are covered with coarse spaced hemispherical granules less depressed than the marginal. Sutures between the plates distinct and deep.

First adambulacral with a nearly straight furrow comb of 6 slightly flattened four-sided spines tapering to a chisellike edge; second and third with a curved series; on the fourth plate an angle appears near the adoral margin which gradually increases in prominence up to the twelfth or fifteenth, and remains prominent to the end of ray. The spines increase to 9 or 10, the 3 or 4 on the apex of angle being the slenderest, somewhat prismatic and compressed. On the adoral end of the series are usually 2 flattened, round-tipped spines, the side to furrow, and on the aboral end 3 or 4 similar but larger ones. The aboral facet of the angle is hollowed out to accommodate the tube foot. Proximally the plates bear 2 or 3 series of tubercular granules (7 to 9 in number); farther along ray where the angle is prominent there are about 15 in three irregular series parallel to margin. On the outer attenuate part of ray a granule spaced from the rest and sometimes slightly enlarged is found just back of the apex of the angle. No pedicellariae. Sutures between the plates unusually deep.

Mouth plates with a straight furrow series of 9 or 10 spines like the adambulacrals except that the inner three become gradually enlarged and more compressed. Suboral granules 8 or 9, following the other margins of each plate, the inner 2 or 3 of the series adjacent to median suture being enlarged into short, stout wedge-shaped spines.

It is noticeable that the ventral plates have more distinct spaces or sutures between them than have those of either *euryplax* or *moluccanus.*

Madreporic body subpentagonal, surrounded by 4 large plates, of which the largest, on the adcentral side, is the primary basal. The madreporite is a trifle smaller than the primary basals of the other 4 interradii, and is situated about one-third the distance between center and inner edge of superomarginals.

Young.—Two small specimens doubtfully referable to this species have less tumid marginals, broader rays, with the median abactinal depression less pronounced than in the adult. Oral spines 9; furrow spines at first 5 increasing to 9.

Type.—Cat. No. 30547, U.S.N.M.

Type-locality.—Station 5648, Buton Strait, Celebes (lat. 5° 35′ S.; long. 122° 20′ E.), 559 fathoms, bottom temperature 39.2° F.; 1 specimen.

Distribution.—Celebes.

Specimens examined.—Three; the type and 2 young specimens doubtfully referred to this species from station 5651, Gulf of Boni, Celebes, 700 fathoms, green mud, bottom temperature 38.7° F.

Remarks.—This species differs from *N. euryplax* in having narrower rays, tumid marginals, narrower and longer inferomarginals, radial abactinal plates which are not conspicuously wider than long, and 9 or 10 oral spines. In *arthrocnemis* the plates are more distinct, the granulation coarser, the primary basal plates larger, the madreporic body surrounded by 4 (not 6) plates, and the dorsal surface of ray is marked by a shallow sulcus, of which the dorsal facets of the superomarginals form the sides. From *N. moluccanus*, *arthrocnemis* differs in having proximally narrower rays, differently formed superomarginals, which on disk extend laterally beyond the inferomarginals (not the reverse), in having coarser granules, larger primary basal plates, shorter furrow spines, especially the middle members, and fewer oral spines, the series of which is not incurved. The inferomarginal plates are narrower and more bandlike, on the ray and the superomarginals are much more numerous. *Nymphaster nora* Alcock has still longer rays (R=6.3 r) very narrow inferomarginals in the interbrachia, 12 furrow spines and 3 plates surrounding the madreporite. In the form of the marginal plates *arthrocnemis* closely resembles *nora.*

NYMPHASTER MESERES Fisher.

Plate 66, fig. 2; plate 67, fig. 2; plate 68, fig. 2; plate 69, fig. 2; plate 92, figs. 4, 4*a*.

Nymphaster meseres FISHER, 1913*a*, p. 639.

Diagnosis.—Similar in proportions and general form to *N. arthrocnemis* but marginal plates not tumid (although ray is sharply 4-angled) and dorsal surface is subplane; sixth and sometimes fifth superomarginal longer than width of dorsal surface (tenth in *arthrocnemis*); third inferomarginal longer than width of its actinal surface; superomarginal and inferomarginal 2-jawed slender pedicellariae regularly present. Width of ray at proximal end of first pair of superomarginals which meet medially equaling first 3.5 to 3.66 superomarginals measured along ambitus; radial abactinal plates hexagonal to roundish; oral spines 9 to 11; furrow spines increasing from 5 or 6 to 10, 11, and 12 far along ray. R=about 60 mm., r=17 mm., R=3.6 r±; breadth of ray at midinterbrachium, 19 mm.

Description.—The abactinal plates are similar to those of *arthrocnemis*, but the primary apicals are smaller, being subequal to the largest radial paxillae, which have 8 or 10 central and 12 to 15 peripheral granules. The papular areas seem to be relatively a little wider in *meseres*, although the specimen is much smaller; 7 longitudinal rows are included in the papular areas, with a few plates of 2 additional rows on some radii.

One of the main differences is in the shape of the superomarginal plates which are like rectangular blocks with plane (not tumid) facets. The sutural line along side of ray is a trifle sunken, as also that of the midradial line on outer part of ray. The plates are sharply oblique in the midinterbrachia and the width decreases more rapidly over the length than in *arthrocnemis*, as indicated in diagnosis. Granules depressed hemispherical, rather coarse, and touching one another, not spaced as in *habrotatus* and *atopus*. Marginal pedicellariae few, slender, in the interbrachia. Terminal plate (of cotype) longer than wide, broadly lanceolate, the pointed end proximal. Superomarginal plates 26+, a small portion of ray being missing.

Inferomarginals longer than width of actinal surface (except first 1 or 2), and very narrow distally; 10 plates near middle of ray corresponding to about 16 adambulacrals; granules and pedicellariae as on superomarginals.

Actinal interradial areas with 5 chevrons of plates which are a trifle swollen as in *arthrocnemis;* granules coarse, slightly spaced, larger in center than on periphery (not so in *arthrocnemis* where they are nearly uniform).

Adambulacral plates with 5 or 6 spines on the first furrow margin, increasing to 11, or even 12; a slight angle appearing on the second or third plate but not becoming at all prominent until the eighth. Subambulacral granules 15 to 18 in 3 irregular series. A very few of the proximal plates with a 2- or 3-jawed pedicellaria near the inner adoral corner.

Marginal mouth spines 9 to 11 (10 or 11 in type), compressed; suboral granules in 2 series, a few of the innermost slightly enlarged.

Madreporic body medium-sized, surrounded by 5 or 6 plates; it is larger than the primary basal plates and is situated slightly less than one-third r from center—about as in *arthrocnemis.*

Type.—Cat. No. 30548, U.S.N.M.

Type-locality.—Station 5115, off northern Mindoro (Verde Island Passage), 340 fathoms.

Distribution.—Known only from type-locality.

Specimens examined.—Two, the type and an example from station 5114, type-locality, 340 fathoms, fine sand.

Remarks.—This species, or perhaps only subspecies of *arthrocnemis*, is most likely to be confused with that form and with *habrotatus.* It differs from *habrotatus* in having square-angled rays with a plane dorsal surface, a closer marginal granulation, the sixth and sometimes the fifth superomarginal longer than width of its dorsal surface (ninth or tenth in *habrotatus*); 10 inferomarginals corresponding to about 16 adambulacrals (13 or 14 in *habrotatus*), coarser actinal interradial granulation; fewer mouth spines (12 to 15 in *habrotatus*); primary apical plates smaller—not conspicuous, whereas they are in *habrotatus.* *N. meseres* seems to be related to both *habrotatus* and *arthrocnemis*, and rather closely, though it is separable readily enough with specimens in hand.

Among the species described by Koehler from the *Investigator* collections the present form comes nearest to *ludwigi*, which, however, has wider superomarginals for they are not longer than wide until after the twelfth plate (fourth or fifth in *meseres*) and the inferomarginals as viewed from below do not become longer than wide until after the fifth or sixth. In *ludwigi* the subambulacral granules are fewer in 2 regular series, and there are no adambulacral pedicellariae. *N. belli* Koehler has the radial plates conspicuously wider than long, while in *N. ternalis* (Koehler, but not Perrier) the marginal plates have different proportions, the adambulacral furrow spines are fewer (8) and pedicellariae much more numerous.

I do not think the species which Koehler identifies as *Nymphaster ternalis* is really that form, apart from the improbability of a West Indian species being found in the Indian region. Judging by Perrier's figure, the marginal plates of *ternalis* are more tumid and the abactinal radial plates larger. Perrier states that the apophysis of the adambulacral plates of *ternalis* starts with the twenty-fourth plate. In Koehler's species it starts on the third or fourth to fifteenth. In most of the species described in this report the apophysis starts near the base of the furrow on the first five adambulacral plates and is a rather conservative character. It is unlikely that so great a variation would be present in a single species. I have examined what purports to be *N. ternalis* from the West Indies, but as it agrees with neither the figure nor description of Perrier I think it likely that in the United States National Museum collection other species than true *ternalis* masquerade under that name. This species has the apophysis starting on the third or fourth plate, and its superomarginals, instead of being swollen on the ray and slightly sunken in the midradial line, slope upward toward the median radial line.

NYMPHASTER HABROTATUS Fisher.

Plate 66, fig. 3; plate 67, fig. 3; plate 68, fig. 4; plate 69, fig. 4; plate 92, figs. 8, 8*a*.

Nymphaster habrotatus FISHER, 1913*a*, p. 639.

Diagnosis.—Rays long and slender as in *N. arthrocnemis*, but not tumid, the dorsal surface of ray evenly arched proximally and oral spines 12 to 15; contour of ray as seen from below even, not constricted at intervals; breadth of ray at inner end of the first pair of superomarginals which meet medially equal to first 3 to 3.5 superomarginals measured on ambitus; superomarginals, as seen from above, wider than long up to the sixth or seventh; the next 2 or 3 squarish; granules round and well spaced; a few marginal 2-jawed pedicellariae; median radial plates slightly wider than long, all slightly elevated; primary apical plates conspicuous; adambulacral plates with proximally 7 or 8 and farther along ray upward of 14 furrow spines; apophysis beginning on second or third plate, but becoming prominent gradually; adambulacral 2- to 4-jawed pedicellariae; third inferomarginal longer than wide as seen from below. R=76.5 mm., r=17 mm., R=4.5 r; breadth of ray at midinterbrachium, 19 mm.

Description.—Abactinal area, circumscribed by the superomarginals, arcuate pentagonal with attenuate sharp corners; abactinal plates slightly elevated even on the interradial areas, but not high enough to be distinctly tabulate. Papular areas comprising 3 or 4 rows on either side of the median radials which are slightly wider than long, subhexagonal, and with 3 to 8 central and 12 to 14 slightly smaller depressed granules; other radial plates subcircular and smaller. Primary basal and central plates conspicuously larger than the others and with more granules. A few entrenched pedicellariae with 2 slender jaws are scattered over the radial areas. Plates of midradial and 2 parallel series on either side (papular area) provided with 6 short pointed lobes (arcuately hexagonal), by which the distal plates touch, but do not quite touch proximally. The 4 or 5 distal plates of the radial and adradial series are slightly wider than long, but the proximal plates are not. The interradial plates are irregularly roundish without lobes, and as seen from within they are not in contact.

Superomarginal plates about 32, conspicuously sloping in the interbrachia and basal portion of ray, forming thereto an arched dorsal surface which gradually and at different points on the ray becomes horizontal or plane. Height of lateral face of ray proximally equaling width of dorsal face of superomarginal but distally slightly exceeding it. Fourth or fifth plate meeting its fellow medially; abactinal surface of proximal plates up to the sixth or seventh wider than long; the next 2 or 3 are about as wide as long, and thence the width diminishes gradually (in *N. meseres*, which somewhat resembles this species, the fifth plate is as wide as long or sometimes slightly longer than wide and the plates abruptly become longer than wide, not gradually; also the abactinal surface of ray is plane with abrupt angles). Lateral angle of ray rounded; side of ray straight as viewed from above, the plates not being tumid. Suture between supero- and inferomarginals in a slight depression. Granules circular, depressed, spaced about their own diameter or slightly less. A few small, entrenched, slender 2-jawed pedicellariae are present. In the interbrachia the superomarginals extend laterally beyond the inferomarginals. Terminal plate small, ovoid.

Inferomarginals nearly square interradially, but the third is slightly longer than width of actinal face; height of inferomarginals about one-half that of superomarginals and on ray about equal to its actinal width the surface being evenly rounded from the inner to outer edge. Ten plates near middle of ray correspond to 13 or 14 adambulacrals. Granulation similar to that of superomarginals, and a few similar pedicellariae are present.

Actinal intermediate plates perfectly flat, in about 5 chevrons, and irregular as to size and shape, but usually with 5 sides. Granules similar in size to those of inferomarginal plates, but more spherical or acorn-shaped. Sometimes 1 or 2 two-jawed entrenched pedicellariae are present in an interradial triangle.

First adambulacral with 7 or 8 slender compressed, blunt spines in a nearly straight series. The first appearance of the apophysis is in the second or third plate, but it does not become very prominent until the eighth to twelfth. The spines gradually increase in number to 12, 13, or 14. The central 3 to 5 spines on the distal plates are shorter and slenderer than the laterals, and on the proximal plates they are slenderer and subequal. In short, they have the usual relations, and the distal plates are longer than wide. Subambulacral granules rather variable. In the type there are 15 to 20, in about 3 series, several of the inner series being enlarged on the first 10 plates into short, granuliform, sharp tubercles. Near the adoral border of a comparatively few of the proximal plates of type is a 2- or 3-jawed pedicellaria in the innermost suboral series. The jaws are slender and curved inward. In specimens from stations 5423 and 5424, which in several details depart slightly from the type, the pedicellariae are more numerous. In the specimen from station 5424 the pedicellariae usually have 3 jaws, and with a few exceptions occur on all the first 25 to 30 plates.

Mouth plates with a long and rather narrow mouth angle; marginal spines 12 to 15, usually 14 in type, similar to the furrow spines but stouter and more compressed, gradually increasing in size toward the inner angle of plate, most of the spines being thin, petaloid, and round-tipped. Suboral granules 12 to 18: a series of 5 or 6 parallel to furrow series are enlarged into flattened tubercular spines.

Madreporic body larger than the primary basal plates, and situated about a third the distance from center to ambitus. It is surrounded by 4 plates, with 2 others encroaching somewhat upon them.

Gonads in a single tuft on either side of the membranous interbrachial septum.

Type.—Cat. No. 30549, U.S.N.M.

Type-locality.—Station 5491, between Leyte and Mindanao, 736 fathoms, green mud, coral; bottom temperature, 52.3° F.; 2 specimens.

Distribution.—Sulu Sea to the Surigao Sea, north of Mindanao, 340 to 736 fathoms.

Specimens examined.—Five, 2 from the type-locality and 3 from the following stations:

Station 5423, Sulu Sea near Cagayanes Islands, 508 fathoms, gray mud, coral sand; bottom temperature, 49.8° F.; 1 specimen.

Station 5424, same locality, 340 fathoms, coral sand; bottom temperature, 50.4° F.; 2 specimens.

Remarks.—This species differs from *euryplax* and *moluccanus* in having narrower rays, which are arched proximally; in having the superomarginals extending laterally farther than the inferomarginals, not the reverse; from *euryplax* further in having more numerous oral spines, more numerous furrow spines, and radial plates not conspicuously widened; from *moluccanus* also in having narrower superomarginals and marginal pedicellariae; from *arthrocnemis* in lacking swollen marginals and the characteristic depression along the ray, in having plane not tumid actinal intermediate plates, more numerous oral and furrow spines, finer granules, marginal and adambulacral pedicellariae; from *atopus* in having 6 (young) to 10 interbrachial superomarginals (not 4), numerous pedicellariae, larger, slightly elevated abactinal plates, more numerous mouth spines, and stouter inferomarginal plates. The characters which separate this form from *meseres* are noted under that species.

NYMPHASTER ATOPUS Fisher.

Plate 63, fig. 4; plate 64, fig. 2; plate 69, fig. 5; plate 70, fig. 4; plate 92, figs. 7, 7*a*.

Nymphaster atopus, FISHER, 1913*a*, p. 640.

Diagnosis.—Differing from other species herein described in having only 4 interbrachial superomarginals; rays slender, the width at outer end of second superomarginals (which corresponds in position to the inner end of the first pair of plates which meet medially, in other species) equaling length of first 3 superomarginals measured on ambitus; superomarginals longer than wide; inferomarginals on ray very slender, resembling terete rods placed end to end; marginal granulation relatively coarse, spaced; abactinal plates small, roundish hexagonal, with few granules; oral spines 9 or 10; adambulacral furrow spines proximally 7 or 8, then 10 or 11; apophysis is prominent from the third plate on; distal plates much longer than wide, with 1 series of granules and a few extra in the angle of the apophysis; about 15 or 16 adambulacrals corresponding to 10 inferomarginals of ray. Cotype, R=43+mm., r=9 mm., R=at least 5 r (tip of ray broken).

Description.—Abactinal area, within the marginal plates, pentagonal and bounded on each side by 4 superomarginals. Abactinal plates small, slightly convex, the papular areas comprising 5 longitudinal series of roundish hexagonal plates and the interradial areas, about 4 chevrons of still smaller roundish or irregularly polygonal ones. Radial plates with 1 central and 6 or 7 peripheral subspherical beadlike granules; the adradial and next adjacent series with 4 or 5 granules and usually no central; the interradial plates with 4 to 6 granules. A very few of the radial plates of type (only) have a delicate pedicellaria with 2 slender jaws longer than the granules.

Superomarginals massive proximally, 22 on longest ray, forming an arched bevel to the margin of interbrachial spaces. Base of ray very slightly arched abactinally—nearly plane—but with a well-rounded, abrupt, slightly swollen angle between the dorsal and lateral facets of the plate. On outer part of ray the dorsal surface is arched so that the distal attenuate portion of ray is subterete. Proximally the height of the plate is about half the width of dorsal surface, and distally about equal to it. The third plate is about as long as wide, but thence the width decreases more rapidly than the length, so that all the subsequent plates are longer than wide. Granulation coarse; granules circular, depressed, subtruncate or convex, and spaced slightly less to slightly more than their own diameter apart.

Inferomarginals slightly tumid and very narrow on the ray, and all are longer than width of actinal surface. Inner edge of first plate about as long as chord of extreme width, or exceeding width of ventral surface alone; second plate slightly narrower; third plate one and one-half times as long as wide. From here the plates become rapidly narrower; and the surface being evenly rounded from the inner to outer edge, they resemble short terete rods placed end to end. Ten inferomarginals near center of ray correspond to 15 or 16 adambulacrals. On the outer part of ray the inferomarginals are about as wide as the adambulacrals, and about half as wide as the superomarginals. In the interbrachia and along proximal half of ray the lateral suture between superomarginals and inferomarginals is slightly depressed owing to the slightly swollen lateral facets of the plates. Granules subspherical, slightly smaller than the superomarginal granules and similarly spaced. Proximally there are about 9 in the length of a plate; distally about 7 or 8.

Actinal intermediate plates in 3 chevrons, the outer reaching middle of second plate. Granules thimble-shaped or acorn-shaped, spaced about as those of inferomarginals and similar to them in size.

First 2 adambulacral plates without perceptible furrow angle and with 7 or 8 rather slender 4-sided spines of about equal width throughout, but tapering to a subtruncate tip somewhat like a wedge. Third plate with angle near proximal side, which rapidly increases in prominence until the sixth to eighth plates, beyond which there is a gradual broadening of the apophysis, as the plates become much narrower owing to the tenuity of ray. As a consequence of this the plates are much longer than wide, the apophysis is broad and less prominent, so that the circular compartments in which the tube feet are lodged are separated by more than their own diameter. Where the apophysis is most prominent there are 10 or 11 furrow spines, the median slender, pointed, compressed, with edge to furrow, the laterals stouter, a trifle longer, tapering, and with flat side to furrow. The distal facet of each hypophysis is slightly hollowed out. The lateral spines of 4 adambulacral plates bend down over the compartment in which the tube feet are lodged—4 or 5 from each distal facet and about 4 from each adoral facet, forming an effective operculum of 16 to 20 converging spines. Suboral granules proximally 6 to 9, conical and subspinose, shorter and thicker than the furrow spines and arranged in 2 series. Far along ray are about 8 or 10 conical granules in a series of 5 to 7 on the outer edge of plate, with a group of 2 to 4 between it and the angular-furrow series. Two or three of the proximal plates of each series have a pedicellaria in the inner series of granules consisting of 2 to 4 tapering jaws.

Mouth plates with a fairly straight furrow series of 9 or 10 spines similar to the furrow spines of the first 2 adambulacral plates, but slightly more compressed, and the inner 2 or 3 are conspicuously larger. Suboral granules 7 or 8 slightly spaced, the inner 1 or 2 of the [median] sutural series being tuberculate.

Madreporic body small, surrounded by 4 plates, of which the adcentral basal plate is the largest; it is situated nearly halfway between center and margin.

Type.—Cat. No. 30550, U.S.N.M.

Type-locality.—Station 5428, Sulu Sea, off Palawan (lat. 9° 13′ N.; long. 118° 51′ 15″ E.), 1,105 fathoms, gray mud; bottom temperature 49.7° F.; 3 specimens.

Distribution.—Known only from the type-locality.

Remarks.—This species is remarkable for having only 4 superomarginal and 4 inferomarginal plates in each interbrachial space; in other words, the second superomarginal is the largest and is in contact with its fellow medially. No other described species has so few; even the young specimens of *arthrocnemis* have at least 6. However, Perrier figures some very immature forms with only 4 interbrachial superomarginals, but these are tiny specimens.

Nymphaster atopus lives in the great depths of the Sulu Sea, which are pretty effectually isolated from other abyssal areas.

Genus SPHAERIODISCUS Fisher.

Sphaeriodiscus FISHER, 1910, p. 171; 1911*d*, p. 167. Type, *Stephanaster bourgeti* Perrier.

SPHAERIODISCUS SCOTOCRYPTUS Fisher.

Plate 79, fig. 5; plate 80, fig. 4; plate 83, figs. 6, 7; plate 92, figs. 10, 10*a*.

Sphaeriodiscus scotocryptus FISHER, 1913*a*, p. 641.

Diagnosis.—In general appearance greatly resembling *Ceramaster granularis* (except as regards the enlarged antepenultimate superomarginals). Differing from *S. ammophilus* (Fisher) and *S. bourgeti* (Perrier) in having much narrower superomarginals, more restricted papular areas, much longer adambulacral plates, with more numerous furrow spines and larger mouth plates. Form pentagonal, with straight sides, produced at angles into rays, only 2 superomarginals in length. Superomarginals narrow, increasing slightly in size up to the third, the remaining 2 being smaller; surface bare, except for scattered granules, and several rows near margin. Abactinal plates granulate, a comparatively few of the radial and adradial series being low tabulate; plates hexagonal on radial regions, generally 4-sided interradially, and irregularly hexagonal on center of disk. Adambulacral plates longer than wide, or as long as wide, with a straight-edged furrow comb of 9 or 10 flattened, rather narrow truncate spines, and spaced from these 2 or 3 subambulacral series of granules, the inner the larger. Mouth plates large, with 15 to 17 furrow spines. Abactinal, marginal, and actinal intermediate spatulate pedicellariae with "sugar-tongs" jaws. R=32 mm., r=22 mm., R=1.45 r.

Description.—Abactinal area pentagonal, the plates being flat and only those of the very restricted papular areas slightly tabulate. All are covered with uniform, depressed, subtruncate, hemispherical granules, those in the central part of the plate being spaced one-third to one-half the diameter of a granule; those on the periphery just touching. Scattered over the radial and interradial regions are numerous small pedicellariae, with 2 narrow jaws abruptly widened and spatulate at the tip, and with a rather narrow base; length of jaw about width of 2 granules. Sometimes the spatulate part is notched or denticulate, sometimes entire. The papular areas are restricted to the radial and either adradial series of plates. There are 9 or 10 radial plates, but only about 6 of the radial and 5 of the adradial series are tabulate. These plates are hexagonal or (being usually a little longer than wide) kite-shaped. In the middle of the papular areas the lateral peripheral granules are slightly lengthened, truncate, and have the appearance of acting as opercula to protect the papulae beneath. The interradial plates are four or five sided, or if six-sided the plates appear to be four-sided with 2 opposite corners cut off.

The plates of the papular areas, seen from the coelomic side, have 6 short, broad lobes, directed slightly downward, by which the plates join. They are most pronounced on the radial plates, and the kite-shaped plates have a strong lateral lobe on either side, the rest being suppressed. The adradial and adjacent series have very short lobes.

Superomarginal plates narrow. First 2 longer than extreme width; third much wider at distal transverse suture than at proximal, and touching its fellow of the opposite side by the distal inner corner. Sixth plate narrower distally than proximally and smaller than the fifth. It meets its fellow of the other side. Seventh plate small and tumid. The plates form a well-rounded margin to the disk, but rather more of the plate faces dorsally than laterally. The plates are surrounded by a series of regular granules resembling those of the abactinal plates and the lateral face of the plate has 2 to 5 additional rows of rather deciduous granules. On the inner margin of the first 4 plates there is an additional irregular series of granules, which sometimes continues part way along the transverse margins. The dorsal surface of the first 3 and practically all the surface of the last 3 plates is bare, except for a few scattered granules and 1 or 2 pedicellariae. Terminal plate somewhat top-shaped, with two truncate tubercular granules on the distal truncate end.

Inferomarginals arched actinally and encroaching upon actinal area more than do the superomarginals upon the abactinal. They are all longer than wide; the lateral face is about half as wide as the ventral and merges with it gradually. The plates decrease gradually in size distad and correspond pretty closely to the superomarginals. The ventral service is bare, except for comparatively numerous widely spaced deciduous granules, but the margins of the plate are granulate for the width of 4 to 6 series except the last 2 or 3 plates, which have only 1 or 2 marginal series. Some of the plates have a lateral pedicellaria.

Actinal intermediate plates flat, granulate, in 7 chevrons, the outline of the plates being irregularly polygonal, and the granulation spaced for half the width, or more, of the granules. The series adjacent to the adambulacrals reaches to the middle of the third inferomarginal and bears an occasional 2-jawed spatulate pedicellaria. Each chevron has an odd interradial plate at its apex.

Adambulacral plates slightly longer than wide, or square, with a nearly straight furrow margin bearing a regular straight-edged comb of proximally 9 or 10, distally 7 or 8, flattened, rather narrow, truncate spines. Proximally these are shorter than the width of plate; sometimes the broader side is toward furrow (especially proximally) and sometimes the edge is to furrow (distally). Spaced from these by a conspicuous interval is a straight longitudinal series of 4 or 5 compressed, tubercular spiniform granules, much shorter than the furrow spines, one of which distally becomes enlarged into a tubercle as often occurs in the Goniasteridae. This tubercle is less evident in *S. ammophilus*. The proximal 5 or 6 plates have 1 and the rest 2 or 2.5 additional longitudinal series of small granules (6 to 12) similar to those of the actinal intermediate plates.

Mouth plates large with the furrow margin about twice as long as that adjacent to first adambulacral plate. Furrow series: 15 to 17 compressed chisel-pointed spines, the inner 3 or 4 gradually enlarged and prismatic, the innermost being widest, and blade-like. Actinal surface with about 3 series of granules parallel to the furrow, a pair just back of the teeth enlarged into prismatic spines; median suture rather prominent; actinal surface of plates slightly convex.

Madreporic body rather small, surrounded by 6 plates, and situated one-third r from center.

The gonads are single, one on either side of the membranous interbrachial septum, situated between the third and fourth longitudinal series of radial plates and about 6 mm. from the margin. No rudimentary superambulacral ossicles.

Type.—Cat. No. 30553, U.S.N.M.

Type-locality.—Station 5425, Sulu Sea, near Cagayan Island, 495 fathoms, gray mud, coral sand, bottom temperature 49.4° F.; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—Although this species is very different from *S. bourgeti* and *S. ammophilus* in having narrow superomarginals and larger adambulacral plates with numerous furrow spines, I think it is referable to *Sphaeriodiscus.* The abactinal plating, marginal granulation, and slightly enlarged antepenultimate superomarginal are characteristic. I have examined the gonads and abactinal plates of *S. ammophilus* and they agree with those of *S. scotocryptus.* In the former the plates of the very restricted papular areas are 4- to 6-lobed, the lobes being short, sharply truncate, and joining closely end to end the lobes of adjacent plates. In the radial series the lateral lobes (2 on either side) are developed more fully than the other 2, which may be lacking. The form of the lobing is exactly similar to that of *S. ammophilus*, even to the larger lateral lobes. It would seem that the very small papular areas are also characteristic of the genus. *S. ammophilus* has single gonads, situated as in *S. scotocryptus.*

Genus **PELTASTER** Verrill.

Peltaster Verrill, 1899, p. 168. Type *P. hebes* Verrill (=*Goniaster nidarosiensis* Storm).—Fisher 1911*d*, p. 171.

PELTASTER CYCLOPLAX Fisher.

Plate 74, fig. 1; plate 75; plate 83, fig. 1; plate 92, figs. 11, 11*a–d*.

Peltaster cycloplax Fisher, 1913*a*, p. 641.

Diagnosis.—Differing from *P. nidarosiensis* (Storm) in having entrenched, 2-jawed, pincer-shaped or "sugar-tongs" pedicellariae instead of the sessile, bivalved type; in having very many more granules on the abactinal plates, more tumid and longer proximal superomarginal plates, and very numerous actinal intermediate pedicellariae; rays longer. General form stellate, with short rays and shallow, arcuate, interbrachia; R=109 mm., r=51 mm., R=2.1 r; breadth of ray at midinterbrachium, 60 mm. Abactinal plates finely granulated, the larger primary plates with 35 or 40 peripheral and 120 central, slightly smaller granules; proximal radial plates surrounded, partially or wholly, by smaller, secondary plates; very numerous small abactinal, broadly spoon-shaped, denticulate pedicellariae; superomarginals proximally very tumid, 15 or 16 to the ray, closely granulate except for a central irregular bare space on many plates; a few superomarginal and inferomarginal pedicellariae; actinal intermediate areas very large, closely granulate, nearly all the plates with 1 or sometimes 2 forceps pedicellariae, so that in the aggregate they appear very numerous, the plates being small; adambulacral plates with 5 or 6 stout, blunt, 4-sided or compressed furrow spines and 2 arcuate series of subambulacral spines (4 or 5 in each series), followed by 12 to 15 granules in 2 crowded, irregular series.

Description.—Abactinal plates all clearly distinguishable and arranged regularly on the radial areas and outer parts of interradial areas, but not very regularly on center of disk. Primary plates of radial areas hexagonal, arranged in a radial series and 3 longitudinal series on either side, these interspersed and surrounded by smaller, irregularly polygonal, roundish, or oblong plates, 6 to 8 about each plate. Proximally the consecutive radial and adradials are separated by oblong or very much compressed, often irregular, hexagonal ones, but near the middle of R these disappear from the radial series and, also successively, a little nearer to center of disk from the other 3 series. For a short distance beyond the middle of R the secondary plates are found only at the sides of the lateral series, but in the other series the lateral plates disappear about as quickly as the transverse ones. The intermediate plates occupy, then, a petaloid radial area extending about to the middle of R, and also the center of disk, but here there is less difference in size between the 2 kinds. Interradial plates numerous, gradually changing from hexagonal to lozenge-shaped. There are many irregular forms, 4- to 6-sided or even roundish toward center of disk. All the plates are covered with a fine, close granulation, the peripheral granules being flattened, truncate, or finger-nail-shaped and distinctly larger than the circular depressed central granules, which decrease slightly in size toward the center of plate. A proximal radial plate has upward of 35 or 40 peripheral and 120 central granules, all having the appearance of being immersed in a soft, transparent matrix. Most of the plates also bear an entrenched sugar-tongs pedicellaria with

2 broadly spoon-shaped denticulate jaws, the width of the rounded or ovoid expanded part sometimes nearly equaling the total height, which equals width of 2 or 2.5 peripheral granules. The base of the pedicellaria is narrower than the rounded or ovoid distal portion and the jaw is constricted just above the base.

The edges of the plate fit together tightly, there being no interspaces, and no papulae can be seen. The 5 primary interradial plates can be distinguished by their slightly greater size.

The papular area is very extensive and can not be seen from the outside. It includes the whole dorsal surface, with the exception of a band averaging 5 mm. wide, adjacent to the marginal plates, and on either side of the interbrachial septum, extending inward nearly to center of disk. Viewed from the coelomic side the abactinal plates are even more regular than from an external view. The large primary plates of the radial area are roundish, with 6 to 8 facets, between each of which is a papula. The secondary plates are more irregular, with 5 or 6 slight indentations separating the margin into as many short lobes; or there may be no lobing but only 5 to 7 unequal facets. The lateral radial plates outside the area of intermediates are more regularly hexagonal.

Superomarginal plates, 15 or 16 to the ray, the proximal 5 or 6 very tumid and abactinal in position, the succeeding plates less tumid and with their transverse axis becoming more and more oblique to the abactinal plane. First plate slightly wider than long; succeeding 5 or 6 plates longer than wide; the remaining plates shortening and increasing in width so that the penultimate is wider than the plates of the midregion of ray, but not quite so wide as the first 2 plates. Granulation close and fine, similar to that of abactinal plate. Most of the plates have 1 or 2 pedicellariae similar to the abactinal. The first 4 or 5 plates have an irregular bare space in the middle, and in this there are irregular groups and lines of granules. Some of the outer plates show a similar bare space, but much smaller. Terminal plate rather obovoid, or ovoid, and narrowed at either end.

Inferomarginals confined mostly to side wall of ray, closely granulate, and often with a pedicellaria. General surface slightly arched but not markedly tumid; first plate as wide as long; the next 7 longer than wide and the remainder wider than long. The fifth or sixth to fourteenth plates do not correspond in the 2 series but even alternate. The plates of the 2 series have nearly the same area; sometimes the superomarginals are a shade larger, sometimes the inferomarginals exceed, especially distally.

Actinal intermediate areas very large, closely granulate, the granules convex and coarser than those of inferomarginal plates. Nearly all the plates have 1 or, near the furrow, 2 entrenched pedicellariae with 2 spatulate jaws often not so wide as those of abactinal surface.

The pedicellariae are so numerous as to closely dot the surface, the plates being rather small, 4-sided (sometimes 5 or 6 near margin), those nearest furrow rectangular and largest, the rest gradually decreasing in size and changing to lozenge-shape, or lozenge-shape with 2 corners cut off (6-sided). There are about 12 chevrons of them.

Adambulacral plates wider than long, close-set. Furrow spines 5 or 6, stout, blunt, 4-sided, or compressed and 3-sided, subequal, sometimes placed slightly obliquely, so that the aboral end of the close comb overlaps the adoral end of the succeeding comb. The spines are as long or slightly longer than the plate, and the armature of the actinal surface is graduated in size from the furrow spines gradually into that of the intermediate plates. First there are 2 arcuate series, each of 4 or 5 prismatic or 4-sided spines, heavier but shorter than the furrow spines, and on the outer part of plate 12 to 15 rather crowded granules in 2 irregular series. Near the end of ray one of the spines of the first actinal series is enlarged into a clavate or acorn-shaped tubercle, and here also the plates may bear a 2-jawed spatulate pedicellaria, but they are not numerous. A very few of the proximal plates may also bear a 2-jawed pedicellaria.

Mouth plates flat, with very regular, straight furrow margin, the 5 pairs of mouth plates completely closing actinostome. Furrow spines 9 to 11, truncate, 4-sided, the innermost much compressed and bladelike. The end of the spines has 1 or more tiny granuliform eminences. Parallel to furrow are 2 series, each of 6 or 7 stout truncate 4-sided or prismatic spines, and on the outer part of plate 18 to 20 granules in about 3 interradially directed series.

Madreporic body large, flat, about twice the diameter of a basal plate, and with very fine, numerous, radiating striae; situated one-third distance from center to inner edge of marginal plates.

The gonads form 2 or 3 tufts on either side of the interbrachial septum and parallel to it. Hepatic coeca large, extending half the length of ray; Polian vesicles large.

One of the rays has been injured at the tip, and now has 2 tips with the bud of a third.

Type.—Cat. No. 30552, U.S.N.M.

Type-locality.—Station 5279, between Lubang and Luzon, southwest of Manila Bay, 117 fathoms, green mud.

Distribution.—Known only from the type-locality.

Remarks.—This species differs from *P. nidarosiensis* (Storm)[1] in having the abactinal plates perfectly distinct, though closely granulated, very many more granules to a plate, very numerous abactinal pedicellariae, more tumid and longer proximal superomarginal plates, very numerous actinal intermediate pedicellariae. The pedicellariae of *P. nidarosiensis* are of the bivalve, sessile type characteristic of *Hippasteria*, whereas in *cycloplax* they are of the entrenched 2-jawed sugar-tongs type, similar to those of *Nymphaster*, and other related genera. If *P. hebes* Verrill is distinct from *nidarosiensis* it will differ from *cycloplax* in practically the same characters as *P. nidarosiensis*. *P. planus* Verrill lacks pedicellariae entirely, and has fewer abactinal granules to the plate, wider and less tumid superomarginal plates, and only 3 or 4 furrow spines.

---

[1] Grieg, Goniaster nidarosiensis, Storm og dens synonymer. Bergens Museums Aarbog, 1905, No. 3, p. 10.

Genus PONTIOCERAMUS Fisher.

Pontioceramus Fisher, 1911c, p. 420. Type, *P. grandis* Fisher.

Diagnosis.—Stellate, with a large disk and relatively short rays. Related to *Plinthaster* Verrill, but differing in having the surface of the abactinal plates perfectly smooth, not covered with minute bosses, in having the plates of the papular areas low-tabulate, and the adambulacral plates with an angular furrow margin armed with numerous short stubby spinelets; no conspicuously enlarged subambulacral spine on distal part of ray. Abactinal and marginal plates bordered by a single series of small granules, the latter also with some on lateral face of ray, all flush with level of plate. Last few superomarginals in contact medially. Actinal intermediate plates reaching far along ray, closely granulate, and with small bivalved excavate pedicellariae about as high as wide. Adambulacral plates proximally very narrow, distally becoming wider; with a large subambulacral toothed bivalved pedicellaria, and 10 or 11 furrow spinelets in angular series. No smaller secondary abactinal plates.

PONTIOCERAMUS GRANDIS Fisher.

Plate 77, fig. 3; plate 78, fig. 3; plate 83, fig. 4; plate 93, figs. 4, 4*a–b*.

Pontioceramus grandis Fisher, 1911c, p. 421.

Diagnosis.—Size large; stellate, with a large disk, shallow interbrachia, and short bluntly pointed rays, arcuately tapering from a very broad base to an attenunate extremity, the last 5 to 8 superomarginals being in contact; abactinal plates numerous, with very smooth surface bordered by immersed granules flush with surface, the central and radial areas having the plates low-tabulate and hexagonal: marginal plates conspicuous, decreasing in size gradually, and bordered by flush granules; actinal intermediate plates numerous, granulate those nearest furrow with 1 or 2 small, denticulate, bivalved pedicellariae; furrow spinelets 11 or 12, short, stout, blunt, forming an obtusely angular series, the apex varying in position between the adoral edge and middle; proximally a large bivalved subambulacral pedicellaria near furrow, the remainder of plate being occupied by rather small granules, those in line with pedicellaria being enlarged and subspinose.

Description.—Abactinal plates numerous, with a very smooth and slightly convex surface, on the radial region regularly hexagonal, and on center of disk and in about 9 longitudinal (radial) series distinctly tabulate, each tabulum surrounded by 6 papulae, the area of tabulate plates reaching about two-fifths R. The papular areas are proximally considerably wider than the area of obviously tabulate plates. Interradial plates flat, irregularly four- to six-sided. All abactinal plates surrounded by a single series of flat squarish granules, set in membrane and flush with surface of plate, those on the radial plates hard to see, and larger on the lateral than on the transverse margins of tabulum.

The median radial plates, as viewed from the inner or coelomic side, are wider than long with 8 short truncate lobes in the middle third of the series; proximally the plates are roundish with 6 lobes; distally there are 6 lobes, and the plates are wider than long; the adradial and 2 adjacent series have successively shorter lobes, which are strongest on the adcentral side, while the other plates of the papular areas are roundish with slight indentations to allow the passage of the 6 pupulae. The interradial plates are lozenge-shape, sometimes with the corners truncated. In the case of the radial plates the transition between the 6- and 8-lobed plates is caused by the gradual splitting of each distal and proximal lobe into two.

Marginal plates conspicuous. Superomarginals (30 to a ray) form an even, slightly arched bevel in interbrachium, but on ray a rounded angle, being there somewhat wider than high. Proximal superomarginals decidedly wider than long, the width very gradually and uniformly decreasing toward the end of ray, while the tumidity of the plates gradually increases. Plates surrounded by a single series of small flush granules forming an inconspicuous border, and in addition, on the lateral face of ray, adjacent to the outer or lower edge, is a second series with a few scattered granules above. On the outer part of ray there is but the single marginal series. The distal 5 to 8 superomarginals are in contact medially, while usually 1 or 2 others touch and segregate 1 or 2 of the distal median radial plates. Terminal plate much broader than long, truncate distally, but roughly cordiform.

On the outer part of ray the inferomarginals extend laterally a trifle beyond the superomarginals. The amount to which the inferomarginals encroach upon disk is variable. The plates form a rounded bevel in interbrachium, but a rounded angle on the ray, and are surrounded by 2 series of granules similar to those of superomarginals, becoming reduced to a single series near the end of ray. In addition the longitudinal borders of plate usually have an additional series, with a few odd granules in the corners or scattered on the lateral face.

Actinal intermediate plates very numerous, those nearest furrow the largest and with the next or next two parallel series forming fairly regular chevrons, the plates reaching to the twenty-first or twenty-second inferomarginal. The other plates are irregularly arranged. All are closely granulate, the granules flat and immersed in thin membrane. The plates next to adambulacrals bear one or two small, rather delicate, bivalved pedicellariae, whose denticulate jaws are slightly wider than high (the larger ones) or as wide as high (smaller) and fit into slight depressions when open.

Adambulacral plates proximally long and narrow, very gradually widening on outer half of R, until near tip; beyond the last actinal intermediate plates they are as wide as long. Each plate is angular toward furrow, the angle being sharper deep in furrow than on margin, and is usually adoral to the middle of plate, varying in position between the middle and adoral margin of plate. Furrow spinelets 11 or 12, stout, short, round-tipped or blunt, much flattened, those near the angle of margin with edge to furrow, the others with flat side thereto. The aboral spinelet of the series is the broadest and stoutest, and often the adoral spinelet is similarily enlarged. This spinelet or really granule is most conspicuous near the end of ray, where the furrow angles, meeting medially from the 2 sides, segregate the tube feet as in *Nymphaster*. The spinelets near either end of the series form an operculum, closing this compartment when the tube feet are withdrawn.

The spinelets are subequal in length, or the median slightly the shorter. The actinal surface proximally is wide enough for only one longitudinal series of unequal granules, but as the plate widens more are added, until distally the plates have an even granular surface, like that of actinal plates. Proximally most of the plates have a large bivalved denticulate pedicellaria, the jaws much wider than high. This occupies a third or a fourth the length of a plate, the remainder of the first actinal series being filled out by compressed, rounded, granules, usually larger than the other actinal granules. The distalmost of these, on the last 6 to 12 plates, is enlarged and tubercular (although inconspicuous), and this, a goniasterid tendency, is carried out, although in a suppressed form.

Mouth plates small, triangular, with a fairly straight furrow margin, bearing 9 or 10 spinelets, similar to those of the furrow series, but heavier, and increasing rather rapidly in size toward the inner end of plate, where the spines are heavy, compressed, and leaf-like. Back of these is a row of flattened, shorter, truncate, or round-tipped spines, the outer part of the plate being granulate, the granules being larger than those of the intermediate plates, spaced, and subspinose. A curious variation is present in 2 specimens from stations 5116 and 5412. One of the teeth at the inner angle is enormously broadened and forms an odd scoop-shovel-like tooth. In another mouth angle 2 are enlarged, 1 more than the other, so that they overlap greatly.

Madreporic body small, near center of disk, surrounded by 5 plates; ridges radiating and coarse.

Anatomical notes.—The specimen dissected was smaller than the type, with R, 106 mm. Intestinal coeca, consisting of 5 long, slender, simple, radiating sacs, about one-third the minor radius in length; Hepatic coeca small, about two-fifths of R in length; stomach small, divided by a constriction into distinct dorsal and ventral divisions; Polian vesicles large, 1 in each interradius; ampullae double. Interbrachial septa membranous; along the ray are numerous accessory septa parallel to the interbrachial, and extending from margin nearly to ambulacral plates. There are 8 of these between the second and twelfth superomarginals; thence they become very small. Gonads in a single tuft on either side of the interbrachial septum, at about the middle of r.

Type.—Cat. No. 28657, U.S.N.M.

Type-locality.—Station 5273, off western Luzon, 27 miles southwest of Corregidor Light, 114 fathoms, mud, shells, and coral sand; 1 specimen.

Distribution.—Southwestern Luzon to Bohol, 114 to 200 fathoms, on green mud, mud, shells, and coral sand, temperature range 50.2° to 54.8° F.

Specimens examined.—In addition to the type, 4 specimens from the following stations:

Station 5116, mouth of Balayan Bay, Luzon, 200 fathoms, bottom temperature 50.2° F.; 1 specimen (large).

Station 5412, between Cebu and Bohol, 162 fathoms, green mud, 54.8° F.; 3 specimens.

Station 5417, between Cebu and Bohol, 165 fathoms, gray mud, sand, bottom temperature 54.4° F.; 1 specimen.

Remarks.—This genus differs from *Circeaster* in lacking the abruptly larger abactinal plates of rays, in having smooth marginals, and regular tabulate radial plates; and from *Lydiaster* in the character of abactinal, marginal, and adambulacral plates. *Lydiaster* is more nearly related to *Circeaster* than to *Pontioceramus*. *Ceramaster* is distinguished by the wholly granulate tabulate abactinal plates and *Eugoniaster*, which is perhaps the most nearly related form, has the abactinal plates arranged without regularity although "tabulate," and the adambulacral plates are of uniform width throughout.

Genus LITHOSOMA Fisher.

Lithosoma Fisher, 1911*c*, p. 422. Type, *L. actinometra* Fisher.

Related to *Iconaster* Sladen, but differs in having the regular longitudinal radial series of abactinal plates completely surrounded by granules, not on the lateral edges only, and in having the subambulacral granulation short and spaced from the furrow comb, not crowded and graduated into the furrow armature. All plates smooth and bordered by a single series of granules, the plates of papular areas sensibly elevated. Small spatulate excavate pedicellariae on both surfaces. Disk large, rays long, slender, and beyond base of ray composed only of marginal plates abactinally.

KEY TO THE SPECIES OF LITHOSOMA HEREIN DESCRIBED.

a.[1] R=3.7 r; marginal plates broad, more or less tumid; all superomarginals broader than long; width of ray at proximal end of first pair of superomarginals which meet medially equal to length of first 5 superomarginals; furrow margin of adambulacral plates slightly convex, slightly angular, or concavo-convex, but not markedly angular; adambulacral pedicellaria very small, the jaws much less than half as high as furrow spinelets.
actinometra, p. 298.

a.[2] R=4+r; marginal plates narrow, not at all tumid; distal superomarginals longer than broad; width of ray, measured as in *a*,[1] equal to length of first 3 to 3¾ superomarginals; furrow margin with an apophysis separating the tube feet; adambulacral pedicellaria with jaws nearly or quite as long as the furrow spinelets---------------------------------*penichra*, p. 301.

LITHOSOMA ACTINOMETRA Fisher.

Plate 76, figs. 1, 3; plate 84, fig. 2; plate 85, fig. 2; plate 93, figs. 3, 3*a*.

Lithosoma actinometra Fisher, 1911*c*, p. 422.

Diagnosis.—Rays 5. R=155 mm., r=42 mm., R=3.7 r; breadth of ray at base, 49 mm., at eighth superomarginal, 19 mm. General form precisely like *Nymphaster;* disk large, arcuately pentagonal, and produced at the corners into long slender rays which gradually taper to a bluntly pointed extremity and which are composed abactinally of the marginal plates only. All plates smooth, porcelain-like, bordered by a single complete series of granules flush with the general surface; only the adambulacral and mouth plates with granules on surface. Abactinal plates regular, hexagonal, slightly elevated, close-set; superomarginal plates massive, wider than long, the seventh to ninth meeting medially, and encroaching conspicuously upon abactinal area; inferomarginals similar to superomarginals; actinal intermediate plates numerous, extending slightly beyond middle of R; adambulacral plates slightly wider than long to slightly longer than wide, with a curved or slightly angular furrow margin bearing a comb of proximally 6 to 8, and farther along the ray 9 to 11 short blunt spinelets.

Description.—Abactinal area stellato-pentagonal. Abactinal plates hexagonal, in regular radial and parallel series, smooth except for scattered minute irregular elevations (not granules) and bordered by a single complete series of flat immersed granules, squarish or oblong in shape. The plates are very slightly elevated, are very regular in disposition, and are crowded, those of the center of disk being slightly the largest. If somewhat higher they would be called tabulate. No secondary, smaller, intermediate plates. The papulae, 6 about a plate, are practically all over the abactinal area. Many of the plates have 1 or 2 tiny entrenched pedicellariae with 2 or 3 slender jaws scarcely longer than the width of a marginal granule.

Abactinal plates as seen from the inner or coelomic side with 6 regular short lobes, the interval between being arcuate, and the plates nearly or quite touching by means of the lobes. The ventral surface of the plate is raised into a truncate eminence with sloping sides. Viewed from this side, the plates appear to be of a low conical form with the apex removed at different distances from the top.

Marginal plates blocklike massive, the superomarginals, 40 in number, in contact along median line beyond the seventh to ninth, and encroaching conspicuously upon dorsal surface, being wider than high. The first plate is abactinally wider than the following 4, the next 3 plates gradually increasing in width and the following gradually decreasing toward the end of ray, as best shown in the figure. Surface of plate smooth, porcelainlike, and the abactinal surface of ray is nearly plane, or a trifle sunken along median line owing to a slight convexity of the plates. Marginal granules small, immersed in a membrane which nearly or quite obscures their outlines. A variable number, usually 1 to 5, tiny 2- or 3-jawed pedicellariae occur along the transverse margins and also along the lateral margin on the side of ray. The base of each jaw is half or more than half as wide as the length and constricts to a narrow spatulate extremity. The cotype is much more liberally provided with them than the type. Terminal plate much wider than long.

Inferomarginals correspond to superomarginals proximally; distally they alternate. The plates decrease regularly in size, although very gradually on ray, where the lateral face, as seen directly from the side is about as wide as the ventral facet viewed directly from below. The ventrolateral margin of ray is slightly swollen and evenly rounded. Marginal granules and pedicellariae as on superomarginals. Ten inferomarginals at middle of ray correspond to 16 adambulacrals.

Actinal intermediate plates flat and very smooth, in about 6 irregular chevrons, irregular in size and shape, those next to furrow largest and usually four-sided, the others less regular, four- or five-sided. The series next to the adambulacrals extends slightly beyond the middle of R, or to the fifteenth (or sixteenth) inferomarginal, the plates having upward of 6 small pedicellariae each, with a few scattered over the rest of the area, and the marginal granules are similar to those of the marginal plates.

Adambulacral plates with an angular furrow face deep in furrow, the margin varying from a slightly convex contour to a slight compound curve, or a shallow angle near the adoral end or anywhere between the adoral end and middle. On the outer part of the ray the plates are evenly convex on the margin, the convexity of opposite plates meeting in the middle of ray and separating consecutive pairs of tube feet. Furrow comb consisting of proximally 6 to 8, farther along ray 9 to 11, short, blunt, granuliform, subequal spinelets, the mesial more or less compressed with edge to furrow, the lateralmost somewhat thicker and prismatic or flattened with side to furrow. On the outer fourth of ray the furrow spinelets are again reduced to 6 to 8 and at the tip to 4 or 5. Border of plate with a row of unequal subconical immersed granules, and surface with several, usually forming a longitudinal series spaced from furrow comb. One to 3 small pedicellariae usually present, often taking the place of several granules, being surrounded by a smooth area. They are slightly larger than actinal intermediate pedicellariae and have 2 or 3 similar jaws. Far along the ray the aboral granule or spinelet of the furrow series is considerably enlarged over the others. This gradually becomes the tubercular spine (though very small) characteristic of the distal plates of many genera of Goniasteridae. It functions as a sort of operculum to protect the tube feet.

Mouth plates small, rather evenly triangular, the straight furrow margin with 7 to 9 furrow spines, the 2 inner enlarged, heavy, compressed, prismatic, sometimes unequal, either round-tipped or bluntly pointed. Suboral granules 20 to 25 immersed, close-set, the row adjacent to furrow slightly the heaviest.

Madreporic body hexagonal, surrounded by 6 plates, with coarse irregular ridges radiating from center. In the cotype the striae are fine, very meandering, and interrupted, but in the type are fairly straight.

Anatomical notes.—Gonads, a large cluster on either side of the membranous interradial septum, the aperture about 10 mm. from inner edge of marginal plates and 5 mm. from interradial septum. Polian vesicles, 1 in each interradius.

Type.—Cat. No. 28658, U.S.N.M.

Type-locality.—Station 5272, western Luzon, 25.5 miles southwest Corregidor Light (lat. 14° N.; long. 12° 22′ 30″ E.), 118 fathoms, mud, shells, coral sand, bottom temperature 57.4° F.

Distribution.—Off western Luzon, 114 to 118 fathoms.

Specimens examined.—Two, the type and a specimen from station 5273, off western Luzon, 27 miles southwest Corregidor Light, 114 fathoms, mud, shells, and coral sand.

Remarks.—*Dorigona pentaphylla* Alcock from 271 fathoms, Andaman Sea, is closely related to the present form. Although no figures have been published, I think there is little doubt that the two are congeneric, and possibly even conspecific.

LITHOSOMA PENICHRA Fisher.

Plate 76, fig. 2; plate 77, fig. 1; plate 84, fig. 6; plate 85, fig. 1; plate 93, figs. 6, 6*a*–*b*.

Lithosoma penichra FISHER, 1917*b*, p. 90.

Diagnosis.—Differing from *L. actinometra* in having slenderer, longer rays, narrower marginal plates, restricted petaloid papular areas, and more angular furrow margin to the adambulacral plates, the consecutive pairs of tube feet being separated, beyond base of furrow, as in *Nymphaster;* surface of plates and encircling granules as in *L. actinometra;* width of ray at proximal end of first pair of superomarginals (fifth), which meet medially equal to length of first 3 or 3¾ superomarginals measured on ambitus (5 in *L. actinometra*). R=86 mm., r=21 mm., R=4+r; breadth of ray at interradius, 24 mm., at proximal end of fifth superomarginal, 9.5 mm.

Description.—Abactinal plates similar to those of *L. actinometra* except that the median radial plates are wider than long, and to a slighter extent the distal adradials also. The pedicellariae are relatively larger, the combined jaws when open being one-third to one-half the diameter of plate, and each jaw is as broad or broader at base than one of the marginal granules, while in *actinometra* a granule is two or three times as broad as a pedicellaria. Even though the type of *actinometra* is very much larger than that of *penichra*, the abactinal pedicellariae are slightly smaller. The papular areas are petaloid and in extreme width comprise 9 longitudinal rows of slightly elevated plates, leaving a narrow triangular area of flat plates (of about 5 chevrons) free from papulae. Each radial plate has from 15 to 25 four-sided marginal granules flush with the level of the plate. The granules on the corners of the plate are larger than the others. The edge of the plate is sometimes slightly uneven, sometimes very straight.

From the coelomic side of the abactinal integument the plates are arcuately hexagonal with truncate corners (or have short truncate lobes) between which are the circular papular pores. The plates fit tightly together by the lobes, and the surface is strongly convex—very similar to that of *L. actinometra*. In the interradial areas and center of disk the hexagonal plates fit tightly together and are without lobes.

Superomarginals 31 or 32 in number, rather narrow, forming a bevel in the interbrachia, and sloping slightly on the basal part of ray, the border of the ray being gradually rounded and the lateral face of plate low and not sharply marked off from the dorsal. Extreme width of first plate equal to or slightly more than length (about twice length measured along inner margin of plate in *L. actinometra*); extreme width of fifth plate (meeting medially its fellow) equal to length of fifth and sixth, measured on ambitus (in *L. actinometra* corresponding plate equal to nearly 3 plates). Superomarginals of *L. actinometra* all wider than long, but in *L. penichra* a variable number on outer part of ray slightly longer than wide, and all along ray the plates are narrower than in *actinometra*. Pedicellariae few. The distal third or half of the ray lacks granules on the transverse margins of plate; and also to a variable extent the granules are absent along the median suture and outer margin. (In *L. actinometra* the last few plates only may lack marginal granules on all but the outer margin.) Terminal plate slightly wider than long, or as wide as long, tubercular, with an obtuse extremity.

Inferomarginals narrow, except interbrachially, and extending laterally a trifle beyond superomarginals. They are as wide as long, or a little wider than long, up to the fifth or sixth. The specimen from station 5510 has shorter plates, so that the length does not equal width until the middle of ray, or beyond. At middle of ray 17 or 18 adambulacrals correspond to 10 inferomarginals. Pedicellariae scattered along both ventral and lateral surfaces of plates, very variable in number, and usually few.

Actinal intermediate areas as in *L. actinometra*, but the pedicellariae fewer and relatively larger. There are about 6 chevrons of plates, but with the exception of those adjacent to adambulacrals they are rather irregularly arranged.

Adambulachral plates longer than wide, with angular furrow margin (except first 3 to 5 plates), the aboral facet of the apophysis concave and slightly longer than the adoral, which is slightly convex. Furrow spinelets 5 to 7 on the first few plates, increasing to 9 or 10 farther along ray, the mesial spinelets compressed, prismatic, blunt, the laterals broader. The 2 aboral members are the broadest, and have a blunt lanceolate contour, and serve, with the adjacent enlarged adoral spinelet of the succeeding plate, as an opercular covering for the tube feet. In the type there is a distinct interval without spinelets on the aboral facet of the apophysis, the 1 or 2 distalmost spinelets of the series being separated from the rest. Near the center of plate is a pedicellaria, with 2 or 3 broadly spatulate jaws, becoming narrow on outer part of ray. Outer margin of plate, with 5 or 6 convex granules larger than those of intermediate areas; and 2 or 3 form a series with the pedicellaria. Whenever the pedicellaria is lacking there are 2 series of granules, or sometimes 2.5. In *L. actinometra* the pedicellariae are much smaller, and usually 2 or 3 to a plate, the jaws being much less than half the length of the furrow spinelets, but in *L. penichra*, despite its smaller size, the pedicellariae are actually larger, with jaws nearly or quite as long as the furrow spinelets.

Mouth plates with 7 or 8 four-sided, beveled, chisel-shaped furrow spines, becoming heavier and prismatic at inner end of series, and about 8 granules following the other 2 sides.

Madreporic body pentagonal, surrounded by 5 plates and situated one-third distance from center to marginal plates.

Gonads situated as in *L. actinometra.*

Type.—Cat. No. 37004, U.S.N.M.

Type-locality.—Station 5528, between Siquijor and Bohol Islands, 439 fathoms, globigerina ooze, bottom temperature 53.3° F.

Distribution.—Mindoro to Mindanao, 283 to 439 fathoms, globigerina ooze and mud, temperature range 53° to 53.3° F.

Specimens examined.—In addition to the type, 13 from the following stations:

Station 5123, east coast of Mindoro, 283 fathoms, green mud; 1 specimen.

Station 5388, between Burias and Luzon, 226 fathoms, soft green mud, bottom temperature 51.4° F.; 11 specimens (1 with 4 rays).

Station 5510, Iligan Bay, north coast of Mindanao, 423 fathoms, gray mud, fine sand, bottom temperature 53° F.; 1 specimen.

Remarks.—It is not possible, with the limited amount of material, to decide whether this form is a distinct species or a deep-water race of *L. actinometra.* The differences between the specimens have been indicated in the diagnosis and description.

This species greatly resembles a slender-armed *Nymphaster*, without granules on the surface of the plates. The "mimicry" goes even to the characteristic angular margin of the adambulacral plates, with the angular furrow series separating consecutive pairs of tube feet, and to the form of the abactinal, marginal, and actinal intermediate plates.

Genus ICONASTER Sladen.

Iconaster SLADEN, 1889, p. 261. Type, *Astrogonium longimanum* Möbius.

ICONASTER LONGIMANUS (Möbius).

Plate 77, fig. 2; plate 83, fig. 5; plate 93, fig. 2, 2*a*; plate 104, fig. 3.

Astrogonium longimanum MÖBIUS, 1859, p. 7, pl. 1, figs. 5, 6.
Iconaster longimanus SLADEN, 1889, p. 261.

Notes on Philippine specimen.—R=40 mm., r=12 mm., R=3.3r. The specimen is immature, since the gonads have not yet appeared. The abactinal plates are dark brown, bordered by lighter granules, the marginal granules on the radial areas being ivory white. The median radial plates and 2 parallel series on either side lack granules on the transverse margins, those on the lateral margins being correspondingly enlarged and acting as an opercular cover to protect the underlying papulae. The other plates, of which the primary basals are largest, are bordered by a complete series of small oblong granules flush with the surface, those at the corners more or less enlarged and opercular. The surface of the plates is roughened by numerous uniform, spaced, low, minute, blisterlike bosses, the same occurring on the central portion of the marginal plates. Madreporic body surrounded by 3 plates. From the coelomic side the plates are flat and have 6 truncate lobes which meet but do not overlap those of neighboring plates, the lateral lobes being best marked, that on the distal and proximal margins being shorter, often incipient. Papulae 6 about a plate. Superomarginals 14, the third meeting its fellow medially (sixth in Döderlein's Thursday Island specimen; see 1896, pl. 18, fig. 33). These first 3 plates are of nearly uniform width; they do not increase in size as in *Lithosoma* and *Astroceramus* (usually). Each interradial pair of plates is dark brown, while others irregularly along the ray are similarly colored. Actinal intermediate plates surrounded by flat granules and arranged in 3 chevrons with 1 or 2 extra plates next to margin interradially.

The adambulacral armature consists of granules graded in size from outer margin to the 4 short, blunt, subprismatic, almost granuliform furrow spines. The latter are in curved series, the distal end overlapping the proximal end of the succeeding series. Back of these are 2 crowded series of 3 or 4 granules each; then (on the proximal plates) a small oval bare spot, followed, on the outer part of plate, by 5 or 6 small granules like those of the intermediate plates. The subambulacral spines do not become enlarged and tubercular on the outer part of the ray as in *Astroceramus* and *Lithosoma*. The granules of the mouth plates also have the closely banked arrangement, 7 or 8 standing on margin, and the inner only a trifle enlarged. There is no sign of any pedicellariae on the specimen.

Distribution.—East Indies and northern Australia: Malacca, Billiton, Jolo, Aru Islands, Thursday Island (off Cape York, Australia), Percy Island (Queensland).

Specimen examined.—Station 5174, 2.6 miles west of Jolo Light, Jolo, Sulu Archipelago, 20 fathoms, coarse sand; surface temperature, 82° F.

Remarks.—In a recent paper on Australian echinoderms, Dr. H. L. Clark, 1916, p. 36) contends that this species should be called *Dorigona longimana* for the following reasons: *Dorigona* as diagnosed by Gray in 1866 included two species—*D. reevesii* and *D. longimana*

(=*Astrogonium longimanum* Möbius). The first species is held, without dissent, to be synonymous with *Goniodiscus capella* Müller and Troschel, 1842, which in 1865 had been made the type of *Ogmaster* by von Martens. In 1889 Sladen made the second species—namely, *D. longimana*—the type of *Iconaster*. Doctor Clark states that Gray designated no type, and that since *D. reevesii* is invalidated by having been made under another name, the type of *Ogmaster*, "*Dorigona longimana* (Möbius) must be the type of *Dorigona*." If this were correct, *Iconaster* would naturally be a name of later application.

The original description of Gray (1866, p. 7) is as follows:

> V. DORIGONA. Body depressed, 5 rayed, smooth; the dorsal and oral disk covered with many smooth, flat, polygonal squares; the marginal ossicules without any mobile spine.
>
> 1. *Dorigona reevesii* (T. 7, f. 3). Inhab. China or Japan; common in boxes of insects brought from China and Japan.
>
> See *a*. Dorigona longimana=Astrogonium longimanum, *Möbius, Abhandl.* IV (1860) 7, t. 1, f. 5, 6.

The only species in the British Museum was evidently *D. reevesii*, which is also the one formally listed, and hence automatically the type. The reference to *D. longimana* seems to be casual, an "aside," such as Gray frequently indulged in, as, for example, on the same page under *Stellaster*. Here we find "1. *Stellaster Childreni*," followed by "See *a*. *Asterias equestris* Retz. * * * *b*. *Stellaster gracilis* Möbius." We know that the first species is the type, because the genus was described monotypically in 1840. Gray naturally chose a species with which he was personally acquainted.

The following observations are pertinent in judging the merits of this case:

1. A species doubtfully referred to a genus can not subsequently be made its type, especially in place of a figured or described species upon which the generic name appears to be based (*D. reevesii*).

2. The first reviser of a genus can not revise the genus before it is described. In other words, what von Martens in 1865 did with *Goniodiscus capella* does not have a revisional effect on *Dorigona reevesii* (the same species) in 1866. Whoever comes after Gray must choose the type of *Dorigona* upon the data submitted by Gray, not upon what von Martens thought or did before Gray's genus was published. This answers Dr. Clark's statement that *D. reevesii* is invalidated for the type-species of *Dorigona* by having already been made the type of *Ogmaster*.

3. Since Sladen eliminated *D. longimana* by making it the type of *Iconaster*, he became the first reviser, and automatically fixed the type of *Dorigona* as *D. reevesii*. No one is at liberty to change this type. The type of *Dorigona* is *D. reevesii*, first, because it is the

only species listed formally "without doubt," and, second, because the first reviser so fixed it by the simple process of removing the second species from the genus.

Dorigona is, therefore, a straight synonym of *Ogmaster*, and *Iconaster* is a tenable name for *Astrogonium longimanum.*

Dr. David Starr Jordan concurs in this view.

Subgenus GLYPHODISCUS Fisher.

Glyphodiscus Fisher, 1917*c*, p. 173. Type, *Iconaster perierctus* Fisher.

Diagnosis.—Differing from *Iconaster* s. s. in having conspicuously elevated and rough superomarginal plates; a complete series of peripheral granules on the abactinal plates, which, moreover, are perfectly smooth, lacking the tiny blisterlike bosses of *Iconaster;* a less compact adambulacral armature.

ICONASTER PERIERCTUS Fisher.

Plate 79, fig. 4; plate 81, fig. 3; plate 83, figs. 2, 3; plate 93, fig. 1, 1*a*.

Iconaster perierctus Fisher, 1913*a*, p. 642.

Diagnosis.—Differing from *I. longimanus* in having more elevated and rough superomarginals; all the abactinal plates perfectly smooth and with a complete series of peripheral granules; a less compact adambulacral armature with fewer spines and granules. $R=23$ mm., $r=10$ mm., $R=2.3$ r; breadth of ray at inner end of third superomarginals, 6 mm., or the length of the first 3 superomarginals measured on ambitus. Superomarginals tabulate, separated by conspicuous grooves, the surface having irregular elevations but no granules nor blisterlike minute bosses; beyond the second plate they are united on the median line of ray; abactinal area sunken, the plates perfectly smooth with a single peripheral series of granules largest on the radial papular areas; peripheral plates tumid, the others slightly swollen, with a plane surface, but not tabulate; plates of center of disk very conspicuously the largest; inferomarginal plates tumid, the first 3 or 4 perfectly smooth, the remainder with slight roughening; actinal intermediate plates in 3 chevrons, smooth, with a single peripheral series of oblong granules; adambulacral plates small, wider than long with 3 or 4 small, stubby, furrow spinelets and following these, 2 shorter, compressed, flat-sided granules, the outer part of the plate being occupied by 4 or 5 small prismatic granules.

Description.—Abactinal area pentagonal, slightly produced at the corners and sunken below the level of the marginal plates. The plates are perfectly smooth, without the tiny blisterlike elevations of *I. longimanus*, *Astroceramus*, and *Lithosoma.* Five large hexagonal plates symmetrically arranged in a quincunx in the interradial regions, as well as all the plates immediately adjacent to the superomarginals (including 4 or 5 distal median radial plates) are distinctly tumid either in the middle or over the whole surface. Three of the above-mentioned interradial plates nearest center of disk have the convexity in the form of a low mamelon in the middle of the plate. A circle of 10 plates, including the 5 primary basals (the largest plates), encloses a stellate area comprising a central and 5 "infrabasal" plates with a small extra plate between 2 infrabasals. Outside the circle of basals and "infraradials" is a very regular circle comprising 15 plates—5 pairs of large subhexagonal plates abutting against the still larger basals and each with a low central convexity. Between each pair is the broadly oval primary radial plate, from which proceeds a very regular series of 8 or 9 radial plates, that adjacent to the primary radial being abruptly smaller, the rest increasing in size distally. These and a parallel similar adradial series are margined by subtruncate finger-nail-shaped granules which are set slightly below the general level of the plates, and which arch over conspicuous intervals between the plates, and hide the papulae beneath. The other plates are bordered by smaller, very narrow, elongate granules, with a straight outer edge and set a trifle below the level of the surface, for all the plates are very slightly swollen, although the general surface may be plane. The plates of the radial areas, including the midradial and 2 series on each side, are the smallest and have the largest peripheral granules. The papulae are distributed all over the disk, except 1 chevron of large interradial plates.

The plates of the radial areas are 6-lobed, the 2 lateral lobes of each side being the most prominent, bent slightly downward and overlapping a trifle the lobes of adjacent plates. The distal and proximal lobe is really only incipient, truncate, and tightly joined, end to end, with the next plates. Coelomic surface plane or slightly concave, not convex, as in *Lithosoma.*

Superomarginals 7 or 8 to the ray, very massive, conspicuously elevated or tabulate, with an uneven surface much as in *Astroceramus sphaeriostictus*, the interval between the plates being a rather deep sulcus. A similar sulcus follows the midradial line, as the third superomarginal meets its fellow medially, and the remainder of ray is composed of superomarginals only. Seen from above, the first 2 plates are slightly wider than long and nearly of a size, but from this point they gradually, but rather rapidly, decrease in size, the outer plates being a trifle longer than wide or the 2 dimensions equal. Despite the unevenness of the plate, suggesting strongly the condition of *Astroceramus sphaeriostictus*, there are no granules such as are present in that species, but there is a single marginal series of small elongate 4-sided granules overhanging and closing a very narrow groove or channel. A very few plates have a tiny 2-jawed narrow spatulate pedicellaria near the inner margin. Terminal plate wider than long, rather large, tubercular, and cordiform, the surface roughened by minute elevations, but without granules.

Inferomarginals corresponding to superomarginals and much less tumid, the surface being smooth and without irregular roughening or elevations (except on the last 3 or 4 plates). The plates form a rounded margin to the ray, the actinal surface being wider than the lateral, and as seen from below the first plate is a trifle wider than long, while the remainder are a trifle longer than wide. Marginal granules similar to those of superomarginals.

Actinal intermediate plates squarish, smooth, very slightly tumid, arranged in 3 chevrons with an extra plate adjacent to marginal interradially. The interradial plate at the apex of the 2 outer chevrons is the largest of its series, but the innermost chevron has small paired plates behind the mouth plates. What appears to be the odd interradial of that chevron is really the second enlarged plate in the left arm of the chevron, the corresponding right plate being small and wedged out of place. The former usually bears a slender spatulate pedicellaria. The plates are all margined by oblong granules in a single series.

Adambulacral plates small, wider than long, with proximally a slightly convex furrow margin which becomes distally more convex. Furrow spines small, 3 or 4, about as large as the plate, thick, subtruncate, and crowded. Near the end of the ray these are reduced first to 2 (of which the aboral is the larger) and finally to 1. Back of these are 2 shorter compressed, rounded or subtruncate granules, as wide or wider than high, with flat side to furrow and occupying the whole length of the plate. These are followed by 4 or 5 smaller prismatic granules, in 2 series, or simply bordering the small plates so that they appear in 2 series. The small distal plates which have only 1 furrow spinelet, have usually 1 subequal, subambulacral spinelet with 1 to 3 additional granules. Although the subambulacral is slightly enlarged over the furrow spines at the end of the ray, it is not markedly so, and would not naturally be considered as an enlarged spine. Instead of the adoral granule of the first series, a few plates bear a pedicellaria with 2 spatulate smooth jaws which open across the plate, the outer jaw reaching the marginal granules.

Mouth plates small, flat, triangular, with a straight furrow margin having 6 spinelets, the inner 2 compressed and enlarged. Suboral granules, a series of 4 parallel with the furrow series and similar to the subambulacral; back of these, a series bordering the median and outer suture, similar to the outer granules of the adambulacrals.

Madreporic body small, situated one-third of r from center, and surrounded by 3 large plates.

Gonads in a single cluster on either side of the membranous interbrachial septum.

Type.—Cat. No. 30554, U.S.N.M.

Type-locality.—Station 5166, 4.6 miles southeast of Observation Island, Tawi Tawi Group, Sulu Archipelago, 97 fathoms, coral sand, bottom temperature 69.4° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—The generic position of this species is very puzzling. The dorsal skeleton and the very tumid roughened superomarginals would ally it to *Astroceramus.* But the actinal intermediate plates are like those of *Iconaster* and *Lithosoma*, being without central granules. The adambulacral armature is similar to that of *Iconaster*, while suggesting *Astroceramus* in the slightly more differentiated inner subambulacral series and in the presence of a conspicuous transversely oriented pedicellaria. To put these facts in a different way, *I. perierctus* differs from *Iconaster* in having the dorsal radial plates entirely surrounded by granules, and in having the tumid superomarginals roughened by uneven elevations (which, unlike those of *Astroceramus*, do not bear scattered granules). It differs from *Astroceramus* in lacking any trace of marginal and enlarged central actinal intermediate granules, in having the adambulacral armature graded from the short furrow spines to the outer granules, and in the absence of a conspicuously enlarged subambulacral spine on the outer part of the ray.

The types of *Iconaster* and *Astroceramus* are so distinct that I see no utility in merging the 2 genera. For the present, at least, I think it is better to regard the arrangement of the peripheral granules of the radial plates as of less than generic importance, and to rest the distinction between the 2 groups upon the difference in the adambulacral and actinal intermediate armature, as well as upon the absence, in *Iconaster*, of granules on the marginal plates.

Despite the small size of *I. perierctus*, the gonads are well developed.

In the transactions of the Linnaean Society of London for 1909–1910 (vol. 13, Zoology, p. 22), Bell diagnoses *Iconaster gardineri* from Saya de Malha Bank, western Indian Ocean, 125 fathoms. I have examined the type at the British Museum. It is a typical *Nymphaster* related, perhaps, to *N. dyscritus* Fisher.

Genus ASTROCERAMUS Fisher.

Astroceramus Fisher, 1906, p. 1056. Type, *A. callimorphus* Fisher.

Diagnosis.—Related to *Iconaster* Sladen, but differs in having the marginal plates beset with rather coarse, deciduous granules; in having central tubercular granules on the actinal intermediate plates, and in having the furrow spines stout, often compressed, few in number, with 1 to 3 more or less swollen, enlarged, subambulacral spines. Pedicellariae spatulate, entrenched, usually with denticulate jaws. In addition typical species have the proximal superomarginal plates, increasing in size up to the third, thence decreasing, the third or fourth meeting its fellow medially, the ray being composed, dorsally, of the superomarginals only.

SYNOPSIS OF THE SPECIES OF ASTROCERAMUS HEREIN DESCRIBED.

*a*¹. Abactinal plates perfectly smooth, without pedicellariae or central granules; granules of superomarginal plates on edge of ray only; subambulacral pedicellariae few; furrow spines proximally strongly compressed. *lionotus*, p. 310.

*a*². One or two, rarely upward of 5, acorn-shaped, tubercular granules on the middle of the abactinal plates; numerous abactinal broadly spatulate pedicellariae; superomarginal granules scattered over surface of plate; subambulacral pedicellariae more numerous; furrow spines proximally slender, but markedly compressed________________*sphaeriostictus*, p. 313.

ASTROCERAMUS LIONOTUS Fisher.

Plate 81, fig. 1; plate 82, fig. 1; plate 84, fig. 3; plate 94, figs. 2, 2*a*.

Astroceramus lionotus Fisher, 1913*a*, p. 643.

Diagnosis.—Similar in appearance to *A. callimorphus* but differing in having less tumid marginal plates, especially on the ray, slightly smaller abactinal plates, and very strongly compressed, bladelike, subtruncate furrow spines; subambulacral pedicellariae slenderer and longer than the actinal intermediate pedicellariae, not similar to them. R=79 mm., r=22 mm., R=3.6 r; breadth of ray at inner end of first pair of superomarginals which meet medially equal to length of first 3⅗ or 4 superomarginals measured on ambitus; thickness of disk interradially equal to length of 1½ adjacent superomarginals. Abactinal plates flat, smooth, except for minute hyaline bosses, and bordered by small granules flush with the general surface; superomarginal plates massive, increasing in size up to the third or fourth, which meet medially; margin of ray forming an abrupt right angle, with uneven elevations bearing scattered deciduous granules, these encroaching upon surface of plates interradially; a few marginal sugar-tongs pedicellariae; inferomarginals slightly and unevenly tumid, with upward of 30 deciduous granules; marginals bordered by a moniliform series of small granules; actinal interradial areas very similar to those of *A. callimorphus;* furrow spines 4 or 5, compressed, and widened at tip; subambulacral spines 2 or 3, heavy, with proximally, between them a slender spatulate two-jawed pedicellaria; on outer part of ray subambulacral spine single and much longer than furrow spines.

Description.—Abactinal plates perfectly flat, very close-set, hexagonal to roundish-hexagonal, similar to those of *A. callimorphus* but smaller and slightly more numerous. Marginal granules small, with rounded or truncate distal margin, as wide as long, or longer than wide, and 30 to 35 around the larger plates. Surface of plates with numerous, spaced hyaline bosses or convexities considerably smaller than the marginal granules. Papulae all over abactinal surface, except a very small interradial triangle.

Abactinal plates from the coelomic side, flat (not convex as in *Lithosoma*) those of the papular area having 6 lobes, which touch those of neighboring plates, the lateral lobes being narrower than the proximal and distal, these being sometimes suppressed, or represented by only a convexity on the edge.

Marginal plates massive, both series with a right angle marking the margin of ray, the lateral face of ray being vertical. Superomarginals 19 or 20, increasing in size up to the third or fourth, which meet medially; thence the plates decrease in breadth rather more rapidly than in length. First plate dorsally about as wide as long, but the next 2 are increasingly wider than long. There is some variation in the length of the plates; usually the sixth is longer than wide, the length decreasing over the width gradually on the succeeding plates. Interradially and near the end of ray the lateral face is nearly as high as width of dorsal face; elsewhere a little less to a little more than half the width. Plates are smooth, except for 8 to 12 depressed, subglobose, deciduous granules scattered on the margin of ray on slight, uneven elevations of the plate. In the interbrachia these scattered granules encroach upon the dorsal surface, and on outer third of ray are lacking. A few of the proximal plates have an entrenched sugar-tongs pedicellaria with denticulate spatulate jaws. Margin of plates with a regular moniliform series of small pearl-shaped granules, much smaller than those on the surface of plate; these are lacking on the last half dozen plates. Terminal plate large, tubercular, subtruncate, longer than wide, with 2 granuliform tubercles at the tip.

Inferomarginals narrower than superomarginals, and decreasing regularly in size from the first. Proximally they correspond to the superomarginals; at middle of ray they nearly alternate, and at the tip correspond again. The surface of plates (except last 7 or 8) is irregularly tumid and uneven, with proximally 25 or 30 scattered deciduous granules, decreasing in number distad, and becoming more and more confined to the lateral margin of the ray. The plates are surrounded by a moniliform series of granules similar to those of the superomarginals, and on the ventral surface of the first 2 plates there is an entrenched sugar-tongs pedicellaria.

Actinal intermediate plates 4- or 5-sided, in 5 chevrons, the plates reaching to fourth inferomarginal, and isolated plates reaching to sixth. The plates are separated by shallow grooves and bordered by a single series of small subconical or acorn-shaped granules, considerably larger than those bordering the inferomarginals, the surface of plate carrying 1 to 5 larger, unequal, acorn-shaped or subglobose scattered granules. A few of the plates adjacent to furrow have a spatulate sugar-tongs pedicellaria, which is guarded by 1 or 2 granules, and the broadly spatulate denticulate jaws are dark brown at the tip.

Adambulacral plates considerably wider than long proximally, gradually narrowing until they are as wide as long, or sometimes on outer part of the ray longer than wide. Furrow spines 4 or 5, very strongly compressed and broad at the tip, which is roundly truncate, the edge being toward furrow. Spaced from these is a longitudinal series of 2 heavy, though proximally slightly shorter, clavate, blunt spines with sometimes a third smaller granuliform member at the proximal end of series. These spines are sometimes irregularly grooved, on the proximal plates. On the outer part of the ray the furrow spines become shorter, and the subambulacral spines are reduced to a single, heavy, tubercular, blunt, slightly tapering spine, longer than the furrow spines. The outer two-thirds of the plate is bordered by granules similar to those of the actinal intermediate plates, with 2 or 3 slightly larger acorn-shaped granules on the surface. A few of the proximal plates have, between the 2 subambulacral spines, a pedicellaria with 2 rather narrowly spatulate jaws nearly or quite as long as the spines and opening on the transverse axis of the plate. The inside of the jaw is concave.

Mouth plates slightly convex actinally with 9 or 10 strongly compressed furrow spines, the innermost very thin and broad at the tip, and sometimes concave on one side so as to appear scoop-shaped. Corresponding to the subambulacrals are 3 suborals, the outer part of the plate being margined by 8 or 9 granules.

Madreporic body shield-shaped, surrounded by 5 plates of which 3 are larger than itself. It is situated about one-fourth r from center. Striations fine, ridges coarse, interrupted.

Color in alcohol, bleached yellowish.

Gonads in a single tuft on either side of the interbrachial septum.

Type.—Cat. No. 30555, U.S.N.M.

Type-locality.—Station 5523, 6.7 miles northeast of Point Tagolo, northern Mindanao; depth and bottom not recorded; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This form is closely related to *A. callimorphus* Fisher, from 127 fathoms, between Maui and Molokai, Hawaiian Islands. The most obvious difference is in the adambulacral armature, the furrow spines of *lionotus* being much compressed, broadened at tip, and with the edge to the furrow. The form and position of the subambulacral pedicellaria is also characteristic. The jaws are narrower than those of the actinal intermediate pedicellariae, being compressed, while in *callimorphus* the occasional subambulacral pedicellaria is like those of the actinal intermediate plates. In *callimorphus* the madreporic body is surrounded by 3 large plates, and in *lionotus* by 3 large and 2 small ones.

ASTROCERAMUS SPHAERIOSTICTUS Fisher.

Plate 81, fig. 2; plate 82, fig. 2; plate 84, figs. 4, 7; plate 94, figs. 1, 1*a*.

Astroceramus sphaeriostictus FISHER, 1913*a*, p. 644.

Diagnosis.—Similar in general appearance to *A. lionotus*, but differing in having 1 or 2, rarely upward of 5, acorn-shaped, tubercular granules on the middle of the abactinal plates; numerous abactinal, broadly spatulate, or narrowly fan-shaped sugar-tongs pedicellariae; more numerous marginal granules, scattered over the entire surface of marginal plates; larger and more numerous actinal intermediate pedicellariae and coarser tubercular granules; more numerous subambulacral pedicellariae; proximally slenderer furrow spines; commonly only 1 larger subambulacral spine, or if 2, these frequently in a transverse series; slenderer oral spines. R=73 mm., r=22.5 mm., R=3.2+r; breadth of ray at proximal end of third pair of superomarginals (which meet medially) equal to length of first 4⅓ superomarginals measured on ambitus.

Description.—Abactinal plates of papular areas subcircular, or between circular and hexagonal, becoming hexagonal on the interradial nonpapular areas, bordered by a single moniliform series of very small, thin granules which have a rounded outer edge on the papular areas and are more nearly straight-edged interradially. The center of the plate bears 1 or 2, or on center of disk upward of 5, broadly acorn-shaped, tubercular granules equal in diameter to about 2 marginal granules, but very much more conspicuous, appearing from above like whitish globular beads, though in reality subconical. Many of the plates bear a conspicuous 2-jawed, broadly spatulate, entrenched pedicellaria, often close to a granule or between two. The jaws are often crenulate on the margin and about as high as the granule. The surface of the plate is roughened by very regular uniform blisterlike convexities which have a subhyaline appearance. Papular areas include the center of disk and petaloid radial areas comprising about 7 rows of plates. The papulae are crowded, there being as many as 8 around some of the plates. It should be noted that the abactinal plates are arranged in regular series parallel to the median radial.

Superomarginals, 18 in number, are massive and in form are much as in *A. lionotus*, but more tumid interradially. They increase in size up to the third, which is very broad and meets its fellow interradially, thence they decrease rather rapidly in width, the first plate and the fifth being about as long as width of dorsal surface, the sixth and succeeding plates being a little longer than wide. The plates are bordered by a moniliform series of tiny elongate granules, and the surface is tumid, and marked by uneven elevations bearing deciduous spherical granules singly, in groups, or in irregular lines, these being all over the surface but most numerous on the rounded margin of ray. The interbrachial plates are most tumid and have the most numerous granules (upward of a hundred). Far along ray the plates are not very tumid, but have slight uneven eminences and granules scattered all over the surface. On the ray of *A. lionotus* the granules are only on the edge, not scattered all over the plate. The longitudinal suture along the side of ray, as well as the transverse sutures, are at the bottom of a shallow sulcus, due to the tumidity of the plate. No superomarginal pedicellariae. Terminal plate large, as broad as long, with several tubercular granules on the blunt, rounded tip.

Inferomarginals smaller than superomarginals and decreasing regularly in size, being longer than wide beyond the fourth. They form a tumid ventrolateral ridge all along the ray and each plate is independently tumid, and provided with irregular eminences crowded with lines of spherical granules, as in the case of the superomarginals. The first 5 or 6 plates, with an occasional omission, have on the ventral surface or rounded margin a pedicellaria, with fan-shaped jaws, guarded on either side by a prominent granule. The plates are margined by small elongate immersed granules, which overhang a narrow sutural groove. Interradially the plates as seen from the side are nearly as thick as the superomarginals, but they rapidly become smaller beyond the middle of ray. Ten inferomarginals nearest middle of ray corresponding to 30 adambulacrals.

Actinal interradial areas similar in appearance to those of *A. callimorphus* and *A. lionotus*, but pedicellariae more numerous and larger than in the latter and about the same size as in *callimorphus*. Plates with 4 unequal sides, in 5 chevrons, with an unpaired plate at the apex of each and an extra plate or two interradially adjacent to margin. They extend to the fifth or sixth inferomarginal with 1 or 2 isolated plates reaching the eighth. They are bordered by small, unequal, slightly compressed, subconical or subfoliaceous granules similar to those of *A. lionotus*, but a little smaller. Three to 5 or even 6 prominent tubercular acorn-shaped granules stand on the surface of the plate in a group, a line, or scattered. These are a trifle larger than the abactinal granules, much larger than the marginal granules, and slightly larger than the corresponding granules of *A. lionotus.* Most of the plates adjacent to adambulacrals and upward of a dozen others in each area bear a large sugar-tongs pedicellaria, guarded by a special granule on either side. The 2 jaws are spatulate or narrow fan-shaped, with a denticulate rounded distal margin, or the expanded distal part may narrow abruptly to widen slightly at the base. The depressions into which the jaws fit when open are very shallow and inconspicuous.

Adambulacral plates wider than long and in the middle region of ray shorter than in *lionotus* (about 3 of *lionotus* equaling 3½ or 3¾ of *sphaeriostictus.* At the same time the inferomarginals of the latter are a little the shorter, so that in 10 inferomarginals there are about 30 adambulacrals in both species. Furrow margin slightly convex; furrow spines 4 or 5, slenderer proximally than in *lionotus.* On the first few plates they are slender, tapering and not at all or only a trifle compressed and slightly swollen at tip. Throughout most of the ray they are slightly to markedly compressed to a uniform thinness, but either taper toward the point or flare slightly in the other dimension. The tip may be bluntly pointed or broad-truncate or rounded. Subambulacral spines 1 or 2, occassionally 3, heavy and clavate as in *lionotus*, but proximally larger and (as in *lionotus*) frequently marked by shallow longitudinal sulcuses at the broadened end, which sometimes appears to be notched. Instead of forming a longitudinal series the spines usually, when there is more than one, stand in an oblique transverse series, the outer spine the shorter. The majority of plates have but 1 spine. Proximally the enlarged spine is as long as, or a trifle longer than, the furrow spines, but distally is increasingly longer. A majority of the plates even on the outer part of ray (except perhaps the last 12 or 15) have a prominent pedicellaria just adorally to the subambulacral spine and behind the furrow series. The jaws are rather slender, slightly spatulate, and hollow interiorly, and the outer one when open folds into a shallow transverse depression reaching nearly to the outer margin of plate; the other jaw stands upright behind the furrow spines and is nearly or quite as long as they are. A similar but trifle smaller pedicellaria is found on a few of the proximal plates of *A. lionotus.* Outer part of plate with 7 or 8 unequal subconical granules.

Mouth plates only a trifle convex, forming a salient angle which nearly closes the actinostome. Marginal spines 8, the outer slender and tapering, the inner 3 or 4 becoming gradually thicker and more compressed. Two inner subambulacral spines slender and tapering; then in the same series parallel to furrow is a prominent two-jawed pedicellaria (similar to the subambulacral), followed by 1 or 2 thicker spines, near the outer furrow corner of the plate. Six or 7 spaced, unequal, tubercular granules follow the sutural margins of the plate.

Madreporic body surrounded by 5 plates, 3 of predominant size, slightly larger than in *A. lionotus*, and with more numerous radiating branched ridges. Three papular pores are found on the adcentral margin, and the surrounding plates bear 1 to 3 granules each.

Type.—Cat. No. 30556, U.S.N.M.

Type-locality.—Station 5135, 11.9 miles northeast of Jolo Light, Jolo, Sulu Archipelago, 161 fathoms, fine coral sand, bottom temperature 54.7° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This species differs from *A. callimorphus* and *A. lionotus* in having prominent granules and pedicellariae on the abactinal plates, and differs further from the latter in several characters enumerated in the diagnosis. *A. fisheri* Koehler, from 224 to 284 fathoms between the Maldives and India, differs from *A. callimorphus*, *A. lionotus*, and *A. sphaeriostictus* in having a larger disk and shorter rays, only 7 or 8 superomarginals being in contact medially. Moreover, the superomarginals do not at first increase in size and then gradually decrease; they are very nearly of the same dimensions up to the eighth, from which they diminish very rapidly. There are several differences in detail (see Koehler, 1909, pl. 2, figs. 2 and 3). It is quite possible that *fisheri* will prove eventually to be the type of a good subgeneric group, as there are now 3 well-marked species with the marginal plates of the type of *callimorphus*.

Genus CALLIASTER Gray.

Calliaster GRAY, 1840, p. 280. Type, *C. childreni* Gray.

CALLIASTER CORYNETES Fisher.

Plate 86, fig. 1; plate 87, fig. 1; plate 93, figs. 5, 5*a*.

Calliaster corynetes FISHER, 1913*a*, p. 644.

Diagnosis.—R=40 mm., r=15 mm., R=2.66 r; breadth of ray at base, 18 mm. Disk large, rays rather slender and blunt, the interbrachia being wide and rounded. Marginals very massive, wider in outer part of ray than the abactinal area, very tumid, each bearing a very robust, rigid, blunt spine (2 on first plate), the general surface of the plates being smooth; terminal plate large with 5 heavy spines; inferomarginals with 2 stout spines and a few pedicellariae; abactinal plates smooth, bordered by a single series of flat, flush granules, the 5 primary radials and 1 or 2 other radials, as well as the central plate with a heavy upright blunt spine, the remaining median radial plates and most of the larger plates of central part of disk with a central tubercular granule; numerous very broadly spatulate, foliaceous pedicellariae; actinal intermediate plates each with a heavy blunt spine (sometimes 2) and a broadly spatulate entrenched pedicellaria; adambulacral plates with a palmate furrow series of 5 to 7 unequal, rather slender, more or less compressed spines, and distally 1, proximally 2, heavy subambulacral spines, resembling those of the actinal intermediate plates. Differing from *C. childreni* in having much heavier marginal and actinal spines and numerous pedicellariae; from *C. pedicellaris* in having heavy actinal intermediate spines, more numerous and longer furrow spines, and prominent spines in the center of disk; from *C. baccatus* in having longer spines generally, numerous pedicellariae, more numerous furrow spines, and a few prominent abactinal spines, instead of tubercles all over the abactinal area.

Description.—Abactinal plates subcircular, the median radial the largest and convex, the others slightly convex, and all surrounded by a peripheral series of depressed subtruncate, foliaceous granules flush with the surface and overlying the rather conspicuous intervals between the plates. The apical area, enclosed by the primary radials and basals, contains smaller plates of two sizes in two circles surrounding the larger very convex central plate, which, like the slightly larger, but similarly convex primary radials, bears an upright rigid, robust, blunt tubercular spine 3.5 to 5mm. long, and at the base as thick as about half the width of plate. The following one or two plates, or the second following plate, bears a shorter but similar spine, while the remainder, with the exception of the last 5 or 6, have a central tubercular granule, decreasing in size distad. The radial plates inside the apical area, the primary basals, and a few neighboring plates of the disk also have a central tubercle. A number of plates on the disk and proximal portion of rays—about 35 in all—bear a pedicularia with two very broadly spatulate, entire, jaws which fit into well-marked depressions, when open. On some plates, when open, the jaws reach nearly across. Papulae large, the area including all the disk except a very narrow interradial portion, extending on the margin only to middle of the first plate, and the last six or seven abactinal plates. There are six around each plate. The abactinal area of the ray is narrow. From the third superomarginal to the seventh there are only three longitudinal series of plates separating the marginals, and beyond the seventh only one, the width of the area here being less than that of the marginals.

Superomarginal plates, 13, very tumid, and decreasing regularly in size, the first with two rigid tubercular spines in a transverse series, the others with one spine on the margins of the ray. The lateral face of the plate is about as wide as the dorsal. The spine is borne on the summit of a subtubercular tumidity and in height equals the distance between its base and the inner margin of plate. It is smooth, blunt, subcylindrical, very slightly tapering and constricted slightly where it joins the plate. On the upper surface of the second or third to sixth or seventh plates is a small flat granule corresponding to the inner or dorsal spine of the first plate. One superomarginal has a lateral, broadly spatulate, pedicellaria. The plates are bordered by a single series of small elongate granules, similar to those bordering the abactinal plates, but longer. Terminal plate large and subglobular with 5 conspicuous tuberculate terminal spines, arising from bosses on the plate. These spines are longer than the distal superomarginal spines.

Inferomarginals less timid than the superomarginals, with two tubercular spines slightly shorter than the superomarginal spines, in a transverse series. The upper or outer spine is proximally a little longer than the lower, but beyond the middle of ray is reduced to a small tubercle which is even lacking on the last two or three plates. The inner or lower spine retains its length to near the end of the ray, where it becomes rapidly shorter. These spines are either directed outward at a right angle to the body or bent toward the tip of ray. A small but variable number of plates bear laterally or ventrally a very broadly spatulate pedicellaria, and all are bordered by small elongate granules. The first plate usually, and the second plate exceptionally, has a tubercle or a granule, or two to four on the ventral surface.

Actinal intermediate plates unequally 4-sided, in 3 chevrons, the plates reaching along ray, to the fourth inferomarginal and bearing 1, or sometimes 2, heavy cylindrical blunt spines, sometimes slightly flattened at the tip, a trifle slenderer than, but fully as long as, the longest inferomarginal spines. The plates are bordered by small granules similar to those of the marginal plates, but a little shorter. The free edge is convex or subtruncate. The spines are carried on a slight elevation or boss of the plate and at the base of the spine is a broadly spatulate pedicellaria, similar to those of the marginal and abactinal plates. The jaws are as wide as long distally, and hollowed out, while proximally they narrow abruptly.

Adambulacral plates a little wider than long, with a slightly convex furrow margin, bearing a palmate series of 5 to 7 very unequal, rather slender, blunt spines, sometimes slightly compressed, with the narrow side to furrow, or again with the broad side thereto. The 2 or 3 median spines are the longest, while the 2 laterals on either side are successively shorter, all being bound together at the base by membrane. The lateralmost spinelet is usually very short. In a transverse series on the slightly convex actinal surface of the first 13 to 18 plates are 2 blunt or truncate heavy spines like those of the actinal intermediate plates; beyond the thirteenth to the eighteenth plates there is but one spine. At the base of the furrow the inner of these 2 spines is slightly the larger and scoop-shaped at the tip, the concavity being on the outer side. Soon these spines become blunt and cylindrical, though often a little flattened at the tip, and the series continues to the end of the ray, the spines becoming slenderer on the outer part of the ray, although not decreasing in length until near the tip. The outer spine decreases in length, and beyond the thirteenth is very short, disappearing entirely at about the middle of ray. Along the proximal and distal margins of the plates are 3 or 4 more or less pointed granules, and on the outer margin 1 or 2 granules.

Mouth plates rather narrow with 8 or 9 furrow or marginal spines, very short on the outer end of series and increasing rapidly in length toward the inner end, the 2 series of the combined plates being webbed at the base and forming an angular group or comb closing the actinostome. On all the plates but one there is a single upright, long, compressed, subambulacral spine, chisel-shaped at the tip. One plate has 2 such spines. They are similar to the subambulacral, but slightly heavier. The outer and sutural margins are surrounded by a single series of irregular subconical and convex, sometimes compressed, granules.

Madreporic body convex, situated halfway between center and margin of abactinal area, surrounded by 5 plates only the 3 larger of which actually touch the madreporite. Ridges irregular, branching, without definite direction.

Type.—Cat. No. 30557, U.S.N.M.

Type-locality.—Station 5280, between Lubang and Luzon, south of Manila Bay, 193 fathoms, gray sand; bottom temperature 49.6° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This species agrees with *C. pedicellaris* Fisher of the Hawaiian Islands, and differs from *C. childreni* Gray of Japan, and *C. baccatus* Sladen from Cape of Good Hope in having numerous broadly spatulate pedicellariae. *Corynetes* is probably most nearly related to *pedicellaris*, from which it differs in having very prominent spines in the center of disk (the scars of *C. pedicellaris* would indicate rather small tubercles); in having numerous abactinal and a few marginal pedicellariae, in addition to the actinal intermediate pedicellariae; heavy actinal intermediate spines; 5 to 7 instead of 8 or 9 furrow spines, the laterals being very short instead of subequal to the mesial; pedicellariae which are very narrow at the base, the jaws being broad, orbicular, concave, and entire.

Calliaster mamillifer Alcock[1] differs in having the superomarginals (6 in number) in partial contact across the distal third of the rays. These plates "have the form of great globules, each surmounted centrally with a nipplelike spinelet," while the inferomarginal plates are long, broad, and tumid, and each bears *near the suture line with* the superomarginals, a row or a group of large coarse truncated spinelets." Further, the adambulacral plates have only 4 furrow spines and a single "large, coarse, truncated" subambulacral spine. No pedicellariae are mentioned.

---

[1] Alcock, 1893*b*, p. 172, pl. 8, figs. 3 and 4; Andaman Sea, 270–245 fathoms.

Genus ASTROTHAUMA Fisher.

Astrothauma Fisher, 1913*a*, p. 645. Type, *A. euphylacteum* Fisher.

Diagnosis.—Differing from *Calliaster* Gray in having the last superomarginal plate much enlarged and in having the marginal and actinal spines with a roughened or thorny surface; plates smooth, bordered by a single series of granules, and with small 2-jawed upright pedicellariae; marginal and actinal plates with heavy, thorny, or roughened spines; prominent upright smooth or slightly eroded spines on center of disk and basal portion of ray; furrow spines numerous, small, in a close comb; subambulacral spines 2 or 3, large, rough, tapering, and sharp.

ASTROTHAUMA EUPHYLACTEUM Fisher.

Plate 86, fig. 2; plate 87, fig. 2; plate 93, figs. 7, 7*a–c*.

Astrothauma euphylacteum Fisher, 1913*a*, p. 645.

Diagnosis.—Rays 5. R=86 mm., r=24 mm., R=3.5+r; breadth of ray at base, 27 mm.; thickness of disk at interradius, 8.5 mm. Disk fairly large; rays gradually tapering, rigid, blunt; abactinal plates smooth, bordered by a single series of granules; center of disk and proximal third of radial series with prominent, stout, sharp, upright spines and a few scattered small 2-jawed pedicellariae; superomarginals with the distalmost plate much enlarged and each with 2 or 3, abnormally as many as 5, prominent, sharp spines; inferomarginals with proximally 6 to 8 unequal, tapering, sharp, roughened, or thorny spines, becoming reduced to 4 at middle of series, then 3, and finally to 1 or 2 at end; actinal intermediate plates usually with a sharp thorny spine, at the base of which is a small blunt spatulate pedicellaria with 2 swollen jaws; adambulacral plates with 12 to 17 small compressed furrow spines in a close comb, and 2 or 3 sharp, heavy, roughened, subambulacral spines in an oblique series.

Description.—Abactinal plates roundish, broadly elliptical, or subhexagonal, those without spines smooth, slightly convex, and bordered by small flattish granules with a convex or subtruncate margin, the base being obscured by a very thin membrane. The central plate, the primary radials and basals (except one) and upward of 8 other median radial plates bear, on a convexity, an upright, tapering, sharp, heavy spine, the longest (on the primary radials and central plate) about 7 mm. in length, and the surface slightly uneven or rugose, but without thorns or asperities. The radial series extends nearly one-half R, but the spines do not occur on all the plates, 1 to 3 unarmed plates being between the armed plates after the first 2 to 4 spines which are on connective plates. There is a good deal of irregularity in arrangement. A few scattered plates, especially on the radial series, bear a small pedicellaria a little larger than a granule, with 2 oblong, round-tipped slightly swollen jaws, a little higher than wide. The plates with their granules are slightly spaced and are of a chocolate brown, sharply in relief against the dark reddish brown integument beneath. The plates are arranged in very regular series parallel to the median radial, which reaches as far as the enlarged distal superomarginals. The 3 prior superomarginals are separated by the median radial plates only.

The abactinal plates, from the inner side, are strongly lobed or stellate, the median radial or carinal plates being the largest, with 6 to 8 subacute lobes, the 2 or 3 on either side being longer than the distal and proximal. The other plates are smaller, more or less convex, and with 6 lobes. The plates touch by the ends of the lobes. The papulae are distributed all over the disk and rays, and each plate is surrounded by 6 to 10 papulae, the latter number occurring around the proximal radial plates and the larger plates of disk.

Superomarginal plates 15 or 16, massive and tumid, the proximals confined to side wall of the ray, the others gradually encroaching more and more upon the abactinal surface, until beyond the middle, the dorsal surface is slightly wider than the lateral. Proximally the extreme width of plate exceeds the length; then the 2 dimensions become equal; then the length slightly exceeds. The last 2 or 3, with the exception of the distalmost, are a trifle wider than long. The distal plate is enlarged and is as long or longer than the 2 preceding plates combined. On one ray a much enlarged distal has opposite it 3 ordinary superomarginals, and on another ray 2, while 2 other rays have unequal enlarged distals. These enlarged plates are very characteristic of this form. Near the upper end of each superomarginal is a long, conical, rigid, usually sharp, outstanding spine, about as long as the width of its plate, the series extending to the end of ray. In a transverse line with this, on the lateral wall of ray, is a shorter, horizontal, sharp spine, or 1 spine and 1 or 2 smaller companions irregularly placed. Two plates have 4 spines on the lower part of the plate, while 2 others have 3 subequal spines in a transverse series, including the uppermost. The enlarged distal plate has 2 to 4 spines in a single longitudinal series. All these spines are prominent, but they vary in length. In general they become shorter distally. Many of the plates bear a small pedicellaria similar to the abactinal, near the base of one of the lower spines, and sometimes 1 or 2 little granules; otherwise the surface of plate is smooth, the margin being provided with a series of granules similar to those of the abactinal plates. Terminal plate large, tubercular, subglobose, acute proximally, showing scars of 4 to 6 terminal tubercles.

Inferomarginals forming a rounded margin to ray, individually tumid and decreasing regularly in size up to the last, the distal not being enlarged. Four or 5 distal plates correspond to the enlarged superomarginal. The first 5 or 6 plates are wider than long, while the others, except the last 3 or 4, are longer than wide. The proximal plates bear a central group of 6 to 8 spines, becoming reduced to 4 at the middle of ray, then 3, and finally 2 or 1 on the last few plates. The spines are prominent, unequal, tapering, and sharp, the longest being 3.5 to 4 mm. long. A peculiarity which they share with the actinal intermediate and subambulacral spines, is in being roughened by longitudinal rather irregular series of thorny ridges or protuberances, and the perfect spines end in several very short thorns or points. The protuberances on the sides of the spines vary considerably in form, being sometimes carinate, interrupted, ridges, and again formed like blunt rose thorns. The distalmost spines are nearly or quite smooth. Most of the plates bear 1 or 2 pedicellariae, similar to these of the superomarginals, and are bordered by a single series of small oblong semi-immersed granules similar to those of the superomarginals.

Actinal intermediate plates in 3 chevrons, with an odd plate interradially adjacent to margin. The plates adjacent to adambulacrals are 6-sided or sometimes distally 4-sided and reach as far as the middle of the fourth inferomarginal. Nearly all the plates bear a central, tapering, sharp, thorny spine about as long as the inferomarginal spines, and at its base a small, blunt, spatulate pedicellaria with 2 swollen jaws, usually constricted at the middle, 1.5 to 2 times as high as wide. The plates are bordered by slightly convex, or flattish granules immersed in membrane.

Adambulacral plates slightly convex, wider than long proximally, becoming as wide as long in middle of ray, and again wider than long at the tip. Furrow margin slightly convex, bearing a close comb of proximally 12 or 13 spinelets, increasing gradually to 16 or 17 at the middle of ray. The small plates near the tip have a decreasing number, the last 10 plates diminishing from 10 or 11 to 4 or 5 spinelets. The spinelets are slender, compressed, blunt, close together, webbed for nearly half their length, and form a straight or slightly convex-edged comb, abruptly rounded at the corners, where 2 or 3 lateral spinelets, sometimes with the flat side to furrow, become very rapidly shorter, so that the first and last spinelet is quite short. On the actinal surface in an oblique transverse series are usually 2, sometimes 3, large, tapering, pointed thorny or roughened spines, the longest 4.5 mm, and longer than the actinal intermediate spines. When there are 2, the spines are nearly equal and about as long as 2 plates. When there are 3, 1 is shorter, and instead of forming a straight series they stand often in a group. One plate has 4 spines. Most of the plates of the proximal two-thirds of ray bear an upright, entrenched pedicellaria with 2 or 3 subspatulate, often unequal, spiniform jaws, rather larger than the actinal intermediate pedicellariae, and situated usually just adorad of the inner subambulacral spine. The plate is bordered by convex granules covered by a thin membrane. The inner granule of the distal margin is often conical and spiniform.

Mouth plates triangular, the margin adjacent to first adambulacral slightly concave and about as long as that bordering the furrow. Marginal spines 15, all but the 2 innermost similar to the furrow spinelets. The innermost spine is abruptly enlarged, heavy, subprismatic, bluntly pointed: sometimes the second spine is slightly enlarged. In the middle of the actinal surface is a tapering, sharp, smooth, or slightly roughened suboral spine, or 2 such spines (5 plates having 1 and 5 plates, 2). A rather irregular series of convex granules, larger than those bordering the adambulacrals, follows the outer and mesial margins of plate.

Madreporic body rather large, situated one-third r from center and traversed by radiating branched ridges separated by fine striae.

The upper end of each ambulacral ossicle is covered with small spiny projections and the free edge of the plate, between consecutive pairs of ampullae, is thin, serrulate, and bladelike, the serrations being a continuation of the spiny projections of the upper end of the plate.

Tube-feet with a well-developed sucking disk.

Color in alcohol, chocolate brown, lighter beneath, the integument between the abactinal plates being reddish brown.

Type.—Cat. No. 30558, U.S.N.M.

Type-locality.—Station 5412, between Cebu and Bohol, 162 fathoms, green mud, bottom temperature 54.8° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This genus is virtually *Calliaster* with swollen or enlarged terminal superomarginal plates and thorny or roughened spines. The last character suggests *Milteliphaster* Alcock, which has the actinal spines ending in swollen bifid or multifid points. The structure of the actinal spines is apparently the only character which separates *Milteliphaster* from *Calliaster*. In *Astrothauma* the roughened spines resemble those of certain cidaroids. The fact that the swollen terminal superomarginal may be replaced by 2 or 3 smaller plates, abnormally, does not invalidate it, in my opinion, as a generic character. A similar variation may occur in *Pentagonaster* Gray. The growth of the marginal plates must be different from that of *Calliaster* and *Mitteliphaster*, where the superomarginals decrease in size regularly and gradually at the end of the series.

Genus GONIODISCASTER Clark.

Goniodiscaster H. L. Clark, 1909, p. 110. Type, *Goniodiscus pleyadella* (Lamarck).

GONIODISCASTER FORFICULATUS (Perrier).

Plate 80, figs. 2, 3.

Goniodiscus forficulatus Perrier, 1875, p. 234.—Koehler, 1910*a*, p. 61, pl. 7, figs. 1, 2, and 3; pl. 11, fig. 1; pl. 14, fig. 2.

Notes on Philippine specimens.—Koehler has very fully described and illustrated the specimens from India, and has noted wherein these depart from the types, of which he had photographs. He states that figures 2 and 3, plate 7,[1] agree very closely with Perrier's type. The two Philippine specimens also show close resemblance to these figures.

Koehler writes that his specimens varied somewhat, and I have been able to compare the example from station 5159 with the Indian specimen from station 78, coast of Ganjam (Bay of Bengal, south of Puri), the latter example being now No. 2094, Museum of Comparatize Zoology. This example shows a number of differences to the Philippine specimens, which will be noted below.

Specimen from station 5159. R=37 mm., r=15 mm., R=2.4 r. The general features are sufficiently shown by the figures. The midradial line of plates is clearly distinguishable, almost conspicuous, as are also the double series of 3 plates (6 in all) extending from the "primary basal" to the superomarginals. The median plate of each of these series is the largest, and the double series is common to a number of species of this genus. The midradial series of plates sometimes reaches the terminal plates, sometimes is prevented by the last pair of superomarginals meeting on the radial line. A single series of adradials usually extends as far as the third superomarginal from the end. A second parallel series, however, does not extend beyond the third superomarginal. The small globular and thimble-shaped granules are distinctly spaced, at least half the width of the granule, sometimes more, those on the midradial plates being smallest. The granules increase in breadth and length rather abruptly on the adradial plates, although the difference is not great. The marginal granules are lower and broader than the adradial and roundish or polygonal in outline. There are two kinds of abactinal pedicellariae—

---

[1] Koehler, 1910*a*, p. 61.

low bivalved, similar to those of *Oreaster*, lower than the granules and 2 to 2.5 times as long as broad. These occur also on the superomarginal and actinal plates. The second sort are tong-shaped with spatulate jaws, 2 or 3 times as long as the granules, and occur on the adradial plates and second, adjacent, series. The papulae are well shown in Koehler's figure 2, on plate 7. They extend nearly to the end of the ray and to center of disk, but are segregated more or less into 10 areas by the conspicuous double interradial series and the radial series of plates. All these 10 merge, however, with the circular area in center of disk (inside the circle of primary radial plates). The granules guarding the pores are slightly larger than those of the surface of the plate, but are not at all squamiform. The anal aperture is guarded by about 10 granules much larger than the others.

Superomarginals, 12, tumid, the last 3 or 4 with a group of enlarged granules in the center. Terminal plate elongate, with a conspicuous blunt conical spine at the tip. The last 4 or 5 inferomarginals, as noted by Perrier, have a conspicuously enlarged granule in the form of a robust blunt tubercle near the aboral border of plate on the rounded ventrolateral angle.

The actinal intermediate plates are clearly outlined and arranged in 3 chevrons, with 2 plates starting a fourth adjacent to the proximal inferomarginals. On the interradial line are 3 unpaired plates, the middle much the biggest. Granules, hemispherical to thimble-shaped, spaced one-half to three-fourths their own diameter apart.

The adambulacral armature conforms to Perrier's description, and is best shown by the figure. There are 6 furrow spines, webbed for half their length, usually 3 subambulacral spines, the median much enlarged, flattened, and subspatulate, and a row of 4 granules on the outer magin. At the adoral end of the subambulacral series, or between it and the outer series of granules, is a forceps or tongs shaped pedicellaria.

Mouth plates with 9 marginal and 5 to 7 shorter subambulacral spines, back of which are about 7 granules, all these 3 series parallel. In the angle between the second row of granules of the combined plates are upward of 20 granules.

The specimen from Ganjam, India, referred to above, differs in having 8 or 9 furrow spines, while the first series of subambulacral spines are 4 or 5, graduated in length toward the mesial, which is not conspicuously larger than the others. In addition to 3 or 4 compressed granules on the outer edge of the plate there is a second subambulacral series of about 4, somewhat flattened, truncate spines, shorter than the inner series. The abactinal granulation is coarser, and there are no actinal intermediate and abactinal slitlike pedicellariae, nor are the granules enlarged about the papular pores. The distal inferomarginal plates are without tubercles, while the primary radial plates each have a tubercle. The granulation of the actinal surface is finer than in typical *forficulatus;* for instance, the large unpaired actinal plate just back of the mouth plates has about 30 granules in *forficulatus* and 55 or a few more in the Indian specimen, in which, moreover, the outlines of the actinal plates are very indistinct, while in the Philippine specimens they are very distinct. This specimen seems to belong to a distinct variety if the Philippine examples are to be regarded as typical.

Type.—In the British Museum.

Type-locality.—Migupou (probably a Philippine locality).

Distribution.—Philippine Islands to Gulf of Martaban, Burma, and south along the east coast of India to Ceylon.

Specimens examined.—One from each of the following localities: Station 5159, off Tinakta Island, Tawi Tawi Group, 18 fathoms, fine sand and shells. Station 5482, Surigao Strait, east of Leyte, 67 fathoms, sand, shells, gravel.

Subfamily ANTHENOIDINAE, new name.

Leptogonasterinae Perrier (*Leptogonaster* is a synonym of *Anthenoides*).

Genus STELLASTER Gray.

Stellaster Gray, 1840, p. 278. Type, *Stellaster childreni* Gray.

STELLASTER INCEI Gray.

Plate 79, figs. 1–3; plate 80, fig. 1.

Stellaster incei Gray, Proc. Zool. Soc. London, 1847, p. 76; 1866, p. 7, pl. 5, fig. 1.—Sladen, 1889, p. 322.—Döderlein, 1896, p. 307.—Koehler, 1910*a*, p. 80.—Brown, 1910, p. 31.—Simpson and Brown, 1910, p. 50.

Stellaster belcheri Gray, Proc. Zool. Soc. London, 1847, p. 76; 1866, p. 7, pl. 7, fig. 1.—Sladen, 1879, p. 430 (Korean Straits).

Stellaster gracilis Möbius, Neue Seesterne des Hamburger and Kieler Museums, p. 12, pl. 4, figs. 3 and 4 (Abhandl. a. d. Gebiete Naturw. hrsg. v. d. naturwiss. Verein, Hamburg, vol. 4, Abth. 2, 1860).

Notes on Philippine specimens.—Sladen considers *Stellaster incei* and *belcheri* growth stages of the same species. The specimens collected by the *Albatross* are mostly small, and as in the case of Döderlein's specimens from Thursday Island are referable to "*belcheri*."

Among the 26 examples from station 5358, 2 have less than 4 tubercles, 13 have 5 tubercles, not always symmetrically arranged, 10 have 10 tubercles, and 1 has scars of 17, all on the radii. The largest of these specimens has R=40 mm., the smallest R=13 mm. The granules are fine, bead like and spaced, and the membrane very thin. The furrow comb consists of 7 or 8 rather slender spines, the median more compressed than the laterals, and all webbed for half their length. The subambulacral spines are 2 to 4, flattened, round-tipped and unequal, and arranged in a longitudinal series. Just back of the adoral furrow spine is often a prominent pincer-shaped slightly tapering pedicellaria. In very small specimens the subambulacral spines are represented by a row of granules.

Three specimens from station 5483 differ in lacking abactinal tubercles altogether (although larger) and in having a large flattened truncate subambulacral spine. The largest specimen has R 54 mm. The rays are broader than in the examples from station 5358. Ventrally this specimen resembles *Stellaster equestris*, but the marginal plates are decidedly narrower than in a specimen of *equestris* from Usuki, Japan, and the granulation is finer, and quite evidently spaced especially on the dorsal surface. A specimen from station 5432 agrees in having the large subambulacral spine, and there are 5 small dorsal tubercles in addition.

A portion of the abactinal wall of a specimen from station 5483 was examined. This specimen was sexually mature although of only medium size (R=46 mm.). The abactinal plates are large, 5 to 7 in each interradius being the largest, and on the margin bordering the papular areas, scalloped. The carinal plates have 2 short lobes on either side, and the adradial plates on the rays have 2 lobes also on either side, which, as seen from below, overlie the edges of the carinal and the other adjacent longitudinal series. In the central area of the disk the plates have 5 or 6 more prominent lobes. There are 3 or 4 papulae to each pore between the lobes of the plates.

The gonads form a single large cluster, one on each side of the membranous interbrachial septum, 10 in all.

Type-locality.—"North Australia," Gray.

Distribution.—East to the Mozambique coast (Simpson and Brown), India and Ceylon, Mergui Archipelago, Sumatra, and Singapore, Philippines, to Korea (? Sladen), south to New Guinea, Arafura Sea, Torres Strait, North, Northeast and South Australia. Bathymetrical range, 3 to 74 fathoms, usually under 50 fathoms.

Specimens examined.—Fifty-five from the following stations:

Specimens of Stellaster incei examined.

Station.	Locality.	Depth.	Nature of bottom.	Number.
		Fathoms		
5156	Tawi Tawi Group, Sulu Archipelago	18	Fine shells, sand	3
5157	do	18	Fine sand	14
5158	do	18	do	1
5161	do	16	do	6
5357	North Balabac Strait, southwestern end Palawan Island.	68	Coral, sand	1
5358	Off Sandakan Harbor, Borneo	39	Mud	26
5432	Off Corandagos Island, eastern Palawan	51	Sand	1
5483	Surigas Strait, east of Leyte	71	Sand, broken shells	3

Remarks.—The specimens recorded from stations 5432 and 5483 may be a variety of *S. equestris.* I have compared them with a fairly large specimen from Usuki, Japan, which may naturally be regarded as typical, as it agrees in the main with Müller and Troschel's figure (1842, pl. 4, fig. 3). The differences have already been mentioned. Just how constant the width of the marginal plates and the size of the granules are in *equestris* I am unable to state. But in all the Philippine and Borneo specimens the narrower superomarginals, especially interradially, and the smaller spaced granules are constant. The relationship between *inceci* and *equestris* is by no means clear, and some characters other than the dorsal tubercles must be used to discriminate specimens from the territory on the edges of their respective ranges, if not elsewhere.

Genus ANTHENOIDES Perrier.

Anthenoides Perrier, 1881, p. 23. Type, *A. peircei* Perrier; also 1884, p. 246.
Leptogonaster Sladen, 1889, p. 326.—Fisher, 1911*d*, pp. 169, 173.
Antheniaster Verrill, 1899, p. 173.—Fisher, 1906, p. 1067; 1911*d*, pp. 169, 173.

A comparison of *Anthenoides peircei* with *Leptogonaster cristatus* reveals no differential characters of generic importance. *Anthenoides sarissa*, the type of *Antheniaster*, is very closely related to *Leptogonaster cristatus*. It is certainly not in a separate genus. All three species have the body overlaid by a skin of variable thickness, which obscures either rudimentary or fairly well developed granules, and the pedicellariae vary from a low slitlike bivalved type to slender forcipiform. In *A. cristatus* the pedicellariae are extremely variable. All three species have numerous secondary abactinal plates, which increase in number with age. These plates are therefore not characteristic of *Antheniaster* alone, as Verrill believed. There is even greater similarity in their particular form between those of *A. peircei* and *A. cristatus*. *A. peircei*, *A. cristatus*, and *A. sarissa* have similar inferomarginal spinules, while in *A. epixanthus*, *A. granulosus*, *A. lithosorus*, and *A. rugulosus* special spinules are always absent, the plates being granulous. Finally, all except *A. sarissa*, which has not been examined, have the gonads, not single, but fairly numerous in a series, on each side of and parallel to the membranous interbrachial septa.

KEY TO THE KNOWN SPECIES OF ANTHENOIDES.

a^1. Actinal intermediate areas with large slit-like bivalved pedicellariae nearly flush with the general surface; abactinal membrane thick and tough. --*peircei* Perrier.

a^2. Pedicellariae varying from forcipiform to bivalved, but when bivalved always small and not sunken flush with surface.

b^1. Inferomarginals with small lateral spines, at least in the interbrachial arc.
  c^1. Proximally 2 or 3 subambulacral spines, or prominent pedicellariae; abactinal pedicellariae---------- *cristatus* Sladen, p. 329.
  c^2. Proximally 1 prominent subambulacral spine; no abactinal pedicellariae. *sarissa* Alcock.
b^2. Inferomarginals without lateral spines.
  c^1. Pedicellariae only on the adambulacral plates; abactinal granules few and microscopic, visible only when abactinal membrane is dried; the abactinal area has superficially the appearance of being without granules---------- *epixanthus* Fisher.
  c^2. Pedicellariae on the abactinal and actinal intermediate areas, as well as on the adambulacral plates; abactinal granules numerous, at least in center of disk, and easily seen wthout a magnifier.
    d^1. Superomarginals decreasing regularly and gradually in length from the first; granules distributed uniformly all over abactinal area.
      e^1. R=2 r; central granules of each abactinal plate the largest; proximal superomarginal plates coarsely granulated all over; superomarginals all wider than long---------- *granulosus* Fisher, p. 333.
      e^2. R=2.6 r; granules smaller, uniform; superomarginals finely granulated, only a few proximals with coarse central granules; superomarginals at middle of ray longer than wide. *rugulosus* Fisher, p. 338.
    d^2. Superomarginals maintaining their width to near end of ray; granules numerous in center of disk, becoming much smaller and more widely spaced as periphery is approached; superomarginals of proximal half of ray with coarse central granules. *lithosorus* Fisher, p. 336.

ANTHENOIDES CRISTATUS (Sladen).

Plate 78, figs. 1, 2; plate 88, fig. 1; plate 89, fig. 1.

Leptogonaster cristatus SLADEN, 1889, p. 327, pl. 54, figs. 1–7.

Notes on Philippine specimens.—The large series of specimens dredged by the *Albatros* represents all stages from the young to the adult, while the latter exhibit considerable range of variation, particularly in the number and form of the pedicellariae.

The change in proportions due to increasing age is shown by the following table, the measurements being in millimeters:

	R.	r.	R=r.	Number of superomarginals.
1	14	6	2.3	9
2	20	8	2.5	10
3	30	12	2.5	12
4	50	18.5	2.7	20
5	77	25	3+	26
6	116	39	3	30

The last two specimens are larger than Sladen's type.

The chief differences between the young and medium sized specimens (as No. 4) are to be found in the extremely thin membrane and few or no granules of the former. A very young *cristatus* does not appear to belong to the same genus as the adult. In specimen No. 1, for example, the outlines of the abactinal plates are clearly visible and the thin membrane might be described as deciduous. The marginal and actinal intermediate plates are also covered with very thin deciduous membrane. There are no abactinal, marginal, or actinal intermediate granules, or pedicellariae. Four webbed furrow spinelets are present, and the first 2 or 3 adambulacral plates have the rudiment of a subambulacral granule. The mouth plates are prominent actinally and each has 7 furrow or marginal spines. The smooth plates and the deciduous membrane would cause this specimen to be placed in the genus *Ogmaster* if it were adult. It is, in fact, an *Anthenoides* in an *Ogmaster* stage. There are no small secondary adradial abactinal plates.

Specimen No. 2 differs from No. 1 in having 1 or 2 spherical granules on a few of the interbrachial inferomarginals in the position of the future spines, and a very few forcipiform pedicellariae have made their appearance on the actinal intermediate plates; furrow spines 5 or 6.

In specimen No. 3 the abactinal membrane is thicker and more pulpy; 2 or 3 small granules have appeared on the proximal superomarginals and the granules on the proximal inferomarginals have increased to 4 or 5, and are larger, while on the ray a granule takes the place of the small tubercle of the adult. The inner row of the actinal intermediate plates is provided with a central granule (or 3 or 4 on each of the pair back of the mouth plates), while in some specimens of this size a few other intermediate plates may have a central granule; subambulacral granules proximally 2, distally 1; furrow spines, 6.

In No. 4 minute abactinal granules have made their appearance, which, in No. 5, have increased in number, while in the latter the adult condition is further evidenced by numerous small superomarginal granules scattered all over the plate (in No. 4 only a few), a few abactinal pedicellariae, inferomarginal spines, actinal intermediate granules on all the plates, and 7 or 8 furrow spines with a furrow pedicellaria on some plates.

The granules increase in number in the large specimens and the marginal spines become more prominent and more numerous. Interbrachially there are as many as 6 or 7 in large specimens, and exceptionally 9, some of them being grooved, and bifid. The longest are about 2 mm. On the outer half or third of the ray there is but 1 aboral appressed spine to a plate. Sladen figures a terminal plate with 2 spines. In small specimens there are usually 4 or sometimes 5 (as in *A. sarissa*). In the adults I find scars of 4 or 5.

An example from station 5520 has small forcipiform pedicellariae, such as are figured by Sladen (1889, plate 54, fig. 6), scattered thickly over the abactinal and proximal superomarginal plates, with a few on the outer end of the proximal inferomarginals. A large specimen from station 5212 (No. 6 of the foregoing table) has the abactinal pedicellariae less numerous and of a bivalved form, the jaws being truncate, as wide as high, or wider than high. A specimen from station 5394 has rather more numerous abactinal pedicellariae of the same form, while another from 5395 has pedicellariae of the forceps shape with shorter jaws than the figure of Sladen, together with others which might be classed as bivalved with truncate jaws higher than wide. In this specimen the pedicellariae are intermediate between the two extremes.

In the example from station 5394, above referred to, the pedicellariae on the actinal intermediate plates adjacent to the adambulacrals are unlike Sladen's figure 7, but are of the typical bivalved type, being quite similar to the pedicellariae of *Hippasteria.* The jaws are truncate and sometimes twice as wide as high. A few are scattered over the rest of the interradial area. The example from station 5520, which has the very numerous abactinal forcipiform pedicellariae, has the actinal intermediate pedicellariae smaller and either bivalved or of the type figured by Sladen; or with spatulate, rounded jaws intermediate between the two. Specimen No. 6 from station 5212 has a very few actinal intermediate bivalved pedicellariae, a short conical tubercle occupying its place on the other plates. A specimen from station 3595 has the tubercles more prominent, and present on plates near the margin, as well.

I have been able to compare *Anthenoides peircei* directly with *cristatus.* The actinal pedicellariae of *peircei* are bivalved, but low, resembling those of *Oreaster.* The difference is not of generic importance, however. If the jaws were a little higher the pedicellariae would be like those of *cristatus* from station 5394. In my key to the *Goniasteridae* (1911 *d*, p. 173) I relied on the form of the pedicellariae and the presence of abactinal and superomarginal granules to separate *Leptogonaster* from *Anthenoides. Anthenoides*, it appears, has rudimentary dorsal granules, which, with the variations of *Leptogonaster cristatus*, bridge the small gap between the two genera. The enlarged group should therefore be known by the older name *Anthenoides*, which includes also *Antheniaster* Verrill. Sladen was in doubt as to the validity of his genus, as he recognized its close affinity to *Anthenoides.* His conclusion that *Leptogonaster* was distinct was justified, because Perrier described the dorsal skeleton of

Anthenoides as "reticulated." Although secondary plates are present on either side of the carinal series and adradial series, the skeleton has not the reticulated form which one associates with *Anthenea.*

Anatomical notes.—Intestinal coeca composed of 5 long bifid divisions, each terminal division lying on either side of the membranous interbrachial septum to which it is attached by filaments of tissue. Hepatic coeca extending nearly half the length of ray; dorsal stomach sharply divided from the ventral; retractors of stomach attached to upper end of second ambulacral ossicle, to the proximal edge of the ⅄-shaped first ossicle, and to the dorsal integument. Polian vesicle in each interradius. Gonads arranged in a series parallel to and near the interradial septum. They are not well developed in the specimen dissected, but from 6 to 10 small tufts can be counted in each series. In *Anthenoides peircei* the gonads are similarly disposed.

On the proximal part of the radial area and center of disk the primary plates in regular longitudinal series are surrounded by irregular small secondary plates which on the distal part of their area are found only *between* the rows of primary plates. These secondaries are entirely lacking on the radial areas in immature specimens. Small examples may have a few in the center of disk, but the difference in size between them and the primary plates is not so marked. These secondary plates have 5 or 6 short lobes with truncate facets which join truncate facets of the primary plates. The number of secondary plates varies with age, an old specimen having many, which proximally completely surround the primary plates, while in smaller examples the plates are fewer and are found between the primaries. On the coelomic side some of the secondary plates are raised into a keel, the keels radiating, 4 to 6, quite regularly and acting as connecting ossicles between adjacent rows of primary plates, and sometimes between consecutive plates of the same series. Other secondaries, out of position, lack the keel. Distally beyond the area of secondary plates the primaries are externally roundish, with truncate facets, or they may touch without a flattening of the periphery. The papulae are generally distributed all over the abactinal area in fully adult specimens and occur 1 to an area, as a rule, though between secondary plates occasionally 2.

I have examined the dorsal skeleton of *Anthenoides peircei* and it conforms to the arrangement in *cristatus*, although minor specific differences are observable. For example, the secondary plates lack a special internal keel, and, the specimen being smaller, there are fewer plates. When the abactinal integument of *peircei* is cleared with caustic potash numerous minute grains are observable, much smaller than the dorsal granules of *cristatus.*

Type.—In the British Museum.

Type-locality.—*Challenger* station 204, off Tablas Island, Philippines, 100–115 fathoms, green mud.

Distribution.—Philippine Islands, 102 to 279 fathoms, on green mud, globigerina, sand, and hard bottom; temperature range 53.3° to 61.3° F.

Specimens examined.—Eighty-eight.

Specimens of Anthenoides cristatus examined.

Station.	Locality.	Depth.	Nature of bottom.	Number.	Bottom temperature.
		Fathoms.			*°F.*
5117	Balayan Bay, Luzon	118		1	
5121	East coast of Mindoro, 9 miles southeast Malabrigo light.	108	Dark green mud.	2	
5212	East of Masbate Island	108	Gray sand, mud.	3	59.9
5367	North of Mindoro (Verde Island Passage)	180	Sand	1	
5369	Northwest of Marinduque Island	106	Black sand	19	
5375	do	107	Green mud	53	
5382	Ragay Gulf, Luzon	128	Mud	1	
5394	Between Samar and Masbate	153	Green mud	2	
5395	do	140	Hard	1	
5454	Albay Gulf, Luzon	146		1	
5505	Off northern Mindanao, 7.7 miles northwest Macabalan Pt. Light.	220		1	
5516	Off northern Mindanao, 9.7 miles northeast Pt. Tagolo Light.	175	Globigerina	1	54.3
5520	Off northern Mindanao, 4.5 miles southwest Pt. Tagolo Light.	102		1	61.3
5536	Between Negros and Siquijor	279	Green mud	1	53.5

Remarks.—*Anthenoides sarissa* Alcock from the Andaman Sea, 130 to 150 fathoms, is very close to immature *cristatus.* The subambulacral spine is more prominent than in small *cristatus*, however, and the secondary abactinal plates are described as inlaid everywhere between the large plates, showing perhaps that they are more numerous than in *cristatus.* The figure (Alcock, 1894, pl. 2, fig. 4*a*), however, does not indicate on the ray more than an adradial series.

A small specimen has a fairly large solitary coral of the genus *Flabellum* partly engulfed.

ANTHENOIDES GRANULOSUS Fisher.

Plate 88, figs. 2, 3; plate 94, figs. 4, 4*a*–*b*.

Anthenoides granulosus FISHER, 1913*a*, p. 647.

Diagnosis.—Similar in general appearance to *A. epixanthus* (Fisher) but differing in having much more numerous and coarser abactinal and marginal granules; numerous small abactinal and actinal intermediate, bivalved pedicellariae; more numerous adambulacral pedicellariae, which are relatively larger; slender, and slightly more numerous furrow spines, and more numerous oral spines. R=79 mm., r=39 mm., R=2 r; breadth of ray at interbrachium, 43 mm.; disk very large with open, arcuate interbrachia and short, tapering, bluntly pointed rays; whole surface overlaid by soft membrane, obscuring the underlying plates, especially the abactinals, which are covered with spaced granules larger than in *epixanthus;* marginal plates covered all over with spaced granules, coarsest on outer part of plate, and more numerous than in *A. epixanthus;* no marginal spines; actinal intermediate granules coarse and numerous; furrow spines slender, compressed, 6 to 9, the adoral end of the plate with a large, slender, forcipiform pedicellaria, and 1 to 3 more on the actinal surface; subambulacral spines, 1 to 4, according to the number of pedicellariae, which they partly replace; oral spines 13 to 15, with several suboral pedicellariae and numerous suboral granules.

Description.—This species so closely resembles *A. epixanthus* (Fisher) of the Hawaiian Islands that the description will be in the form of a comparison. The entire animal is overlaid by a soft, fairly thick, membrane, obscuring the outlines of the abactinal plates (which are arranged as in *epixanthus*). The membrane is thrown into fine wrinkles and reticulations, partly due to the numerous unequal spaced granules beneath. These granules are much more numerous and much larger than in *epixanthus* and become visible when the membrane is partly or wholly dried. They increase in size from the center of disk toward the periphery, and the central granules of each plate (especially near margin) are larger than the peripheral. The number of granules to a plate is between 15 and 20. In *A. epixanthus* the granules are practically microscopic (as in *A. peircei*) uniform in size and scarcely a tenth the size of an average granule in *granulosus.* They are so small that the membrane is smooth even when dried, while in *granulosus* it is very rough. Scattered over the abactinal plates are numerous small pedicellariae about the size of largest granules, with 2 curved truncate jaws as wide as high, or wider than high. They resemble split granules.

Papulae frequently very dark brown (as in *epixanthus*), confined to petaloid radial areas, confluent at center of disk. As is usual in this genus, there are smaller secondary plates on the proximal radial regions. The secondary plates are lobed, and partly or wholly surround the carinal, and 1 or 2 parallel series, to either side. They extend on each side of the carinal series nearly one-half R, while the proximal plates of the same series may be entirely encircled by 6 or 8 secondary plates. The secondary plates do not extend very far distad on the lateral portions of the area. The primary plates become smaller and also incipiently lobed at the center of disk so that they are indistinguishable from the secondaries. Over the papular areas, even where there are no secondary plates, the primaries are roundish or broadly elliptical with 5 or 6 incipient lobes, sometimes reduced to simple facets; but on the outer third of the ray the plates may be much wider than long and without any trace of lobing. The secondary plates have 3 to 5 very irregular lobes and are not raised internally into a keel as in *A. cristatus.*

Superomarginal plates (21 or 22 in type) forming a rounded bevel in intertrachia, but on outer third of ray strongly arched, with lateral and dorsal surfaces. The plates are usually decidedly wider than long, but they vary in this respect, for one specimen (station 5622) has the plates of the proximal two-thirds of the series as wide as long. They differ from the superomarginals of *A. epixanthus* in having the entire surface (except on outer third of ray) covered with coarse hemispherical, slightly spaced, granules, those on the border the smallest. The inferomarginals extend slightly beyond the superomarginals and are closely covered with similar granules, which are coarsest on the rounded margin of the ray and decrease in size toward the inner margin. In *epixanthus* the inferomarginal and superomarginal granules are very much fewer and more spaced. They do not cover the whole surface of the plate thickly. On the distal plates the granules are fewer and scattered. The outlines of the marginal plates and the granules are partly visible without drying the specimen. Terminal plate pentagonal to ovoid, as long as broad, or broader than long, with 2 stubby terminal spines. The last 3 or 4 pairs of superomarginals are in contact medially.

Actinal intermediate plates slightly convex, rather irregular, in about 8 chevrons, the series of plates adjacent to the adambulacrals extending to the seventh to ninth inferomarginal. They are closely covered with coarse spaced granules, those in the center being much coarser than the peripheral. In *epixanthus* the large granules are fewer, and the tiny immersed granules in the majority. Many of the plates adjacent to the adambulacrals bear 1 to 3 small 2-jawed pedicellariae slightly smaller than the heaviest granules and similar in form to the abactinal pedicellariae.

Adambulacral plates slightly longer than wide, with a curved or slightly angular furrow margin, or occasionally a nearly straight margin, bearing a comb of 6 to 9, usually 7 or 8, slightly divergent, slender, tapering, but also compressed, bluntly-pointed furrow spines, webbed for half their length. The margin of the comb is curved, the mesial spines being the longest and the laterals the shortest. At the adoral end of the series there is usually a rather long, slender, 2-jawed forcipiform pedicellaria, set back slightly, the jaws being very narrowly spatulate and about as long or a little longer than the adjacent adoral furrow spine. The pedicellaria is larger than the homologous pedicellaria of *epixanthus.* One to 3 similar pedicellariae stand on the surface of the plate sometimes in a longitudinal series. Two or 3 short, blunt, tubercular unequal spines form a series back of the pedicellaria (where these are numerous) or take the place of 1 or more of the pedicellariae. When there is only the adoral pedicellaria it replaces the others entirely. On the outer part of the furrow one of these spines is enlarged (or 2 in a transverse series) and becomes tapering and pointed, and is conspicuously longer than the furrow spines. The outer margin of the plate has several unequal granules. In this species the subambulacral pedicellariae are much more numerous than in *epixanthus*, while the furrow spines are more delicate and compressed.

Mouth plate convex actinally as in *epixanthus* and other members of the genus. Marginal spines in a slightly convex series of 13 to 15 (9 to 11 in *epixanthus*) similar to the adambulacral spines except the inner 3 which very rapidly increase in size and become compressed, round-tipped, or truncate teeth. The spines are webbed for about half their length. Back of the furrow spines is a row of upward of 6 pedicellariae similar to the subambulacral pedicellariae, the rest of the plate being covered with spaced coarse hemispherical or sometimes acute granules. In small specimens only 1 or 2 pedicellariae may be present.

Madreporic body variable in size, fairly large, nearly flat, irregularly roundish, situated a little more than $\frac{1}{3}$ r from center. Striae fine, radiating, and branched.

The gonads are arranged in a series of 6 to 8 tufts on either side of and parallel to the membraneous interbrachial septa.

Type.—Cat. No. 30559, U.S.N.M.

Type-locality.—Station 5626, between Gillolo and Kayoa Islands, Molucca Islands, 265 fathoms, gray mud, fine sand; 1 specimen.

Distribution.—Molucca Islands, 265 to 288 fathoms.

Specimens examined.—Five in addition to the type: Station 5622, between Gillolo and Makyan Islands, 275 fathoms, gray mud, 1 specimen; station 5624, same locality, 288 fathoms, fine sand, mud, 4 specimens.

ANTHENOIDES LITHOSORUS Fisher.

Plate 89, fig. 2; plate 90, fig. 2; plate 94, fig. 6, 6*a–c*.

Anthenoides lithosorus Fisher, 1913*a*, p. 647.

Diagnosis.—Closely related to *A. granulosus*, but differing in having the coarse superomarginal granules confined to the center of plate, surrounded by a conspicuous area with only spaced microscopic grains; abactinal granules fine, subequal, thick on center of disk, becoming smaller and more spaced as the margin is approached, fewer than in *granulosus*, smaller, and the central granules of the plate not larger than the others; superomarginal plates more tumid, the width remaining the same to within 4 or 5 plates of end of ray (regularly decreasing in length in *granulosus*); furrow spines 9 or 10; oral spines

15 or 16. R=80 mm., r=44 mm., R=about 1.8 r. General form similar to that of *granulosus* but the rays are thicker toward the end owing to the heavier superomarginals, the last 6 or 7 pairs of which are in contact medially.

Description.—The abactinal area is overlaid by a thick membrane, which in drying allows the small granules to be seen. These are subequal and about the size of the smallest granules of *granulosus*. Only in the center of the disk are they as numerous as in *granulosus*, and as just indicated they are not larger in the center of the plate (which is a characteristic of *granulosus*). In *granulosus* they are numerous all over the abactinal area, but in *lithosorus* they are closely placed only on the center of the disk, becoming more and more widely spaced as the margin is approached and on the outer part of ray are scarce. Scattered over the papular areas (which are as in *granulosus*) are numerous tiny pedicellariae similar to those of *granulosus*, but larger than the granules (since the granules are very small).

Superomarginals 18, massive and tumid, keeping their width (which exceeds the length) up to about the twelfth to fourteenth plates, and from that point gradually narrowing. As a consequence the rays are distally wider than in *granulosus*, in which the plates narrow gradually from the base of the ray. The first 7 plates have a central group of coarse hemispherical granules, which in a dried specimen, remind one of little heaps of stones. The first plate has about 24 granules and the seventh 5 or 6. The outer plates have only the microscopic granules such as surround the coarse proximal granules. These are invisible until the specimen is dried. Terminal plate pentagonal about as wide as long, with the scars of 5 terminal spines. Inferomarginals encroaching conspicuously upon actinal area and extending interradially slightly beyond the superomarginals. They decrease regularly in width and become rather more tumid as the end of the ray is approached. The first 10 are covered with coarse granules which decrease in size from the edge of ray toward inner margin of the plate. The ninth to eleventh plates have a rapidly decreasing number of granules, the remaining plates, as well as a widening space along the upper margin of the first eleven, being occupied by the minute grains referred to above.

Actinal intermediate plates distinctly tumid with 3 to 10 unequal, coarse, hemispherical granules surrounded by 10 to 20 spaced, much smaller ones, very much as in *granulosus*, except that toward the margin the small granules are fewer and smaller than the corresponding ones in *granulosus;* hence there is more discrepancy in size between the 2 kinds. The plate adjacent to the adambulacrals and a few others have upward of 6, usually 1 to 4, small, 2-jawed pedicellariae similar to those of *granulosus*.

Adambulacral armature similar to that of *granulosus* but there are 9 to 10 furrow spines instead of 7 or 8. Two to 4 forcipiform pedicellariae monopolize the surface of the plate, except for a few granules and a short pointed spine or two in place of pedicellariae. On the outer third of ray there is a well-developed pointed subambulacral spine, sometimes with a small companion, and usually but 1 pedicellaria just back of the proximal furrow spine. Mouth plates similar to those of *granulosus*, with 15 or 16 marginal spines, 1 fairly well developed pointed suboral spine near the inner end of the plate, 5 or 6 scattered pedicellariae and rather widely spaced granules, the 5 or 6 nearest the median suture being largest.

Madreporic body flat, circular, with radiating branched striae.

Type.—Cat. No. 30560, U.S.N.M.

Type-locality.—Station 5301, China Sea, vicinity of Hongkong (lat. 20° 37′ N.; long. 115° 43′ E.), 208 fathoms, gray mud, sand; bottom temperature 50.5° F.

Remarks.—This species differs from *A. cristatus* and *A. sarissa* in the absence of inferomarginal spines, and in having much coarser superomarginal granules, heavier marginals, shorter rays, thicker abactinal integument, more numerous actinal intermediate granules, and in numerous other details of armature. It differs from *A. epixanthus* in having coarser and more numerous abactinal granules, numerous abactinal and actinal intermediate pedicellariae, more numerous and slenderer furrow spines and oral spines, more compactly placed superomarginal granules (which, however, in *epixanthus* form a central, though sparser, group), heavier superomarginals distally and numerous subambulacral forcipiform pedicellariae. The abactinal granulation and pedicellariae will alone separate the two species, the granules of *epixanthus* being microscopic and very widely spaced, and the bivalved granuliform pedicellariae being absent.

ANTHENOIDES RUGULOSUS Fisher.

Plate 85, fig. 4; plate 88, fig. 4; plate 90, fig. 1; plate 94, figs. 5, 5*a–b*.

Anthenoides rugulosus FISHER, 1913*a*, p. 648.

Diagnosis.—Differing from *A. granulosus* in having longer, slenderer rays, narrower marginal plates, rather more numerous and smaller *uniform* abactinal granules, a fine superomarginal granulation (except for a few central coarse hemispherical granules on the proximal plates) and more elevated, pincer-shaped abactinal pedicellariae. R=124 mm., r=47 mm., R=2.6+r; breadth of ray at first superomarginal, 52 mm. Disk large, rays distally narrow, tapering arcuately from wide interbrachia; disk more or less inflated; whole body overlaid by smooth, rather thick, soft skin, minutely wrinkled on the abactinal area and covering a fine, close, uniform granulation; small forceps-shaped, abactinal pedicellariae; superomarginal plates smooth, the membrane covering fine, spaced granules, and on the proximal plates a few scattered coarse central granules; superomarginals of middle region of ray in large specimens longer than wide; actinal interradial areas variable, usually fairly smooth, the plates with central, enlarged, hemispherical granules, as in *granulosus;* the plates adjacent to adambulacrals with a variable number of forcipiform or spatulate, lower, pedicellariae; furrow spines compressed, usually 7 or 8 proximally, varying to 6 to 9, the armature in general similar to that of *A. granulosus;* oral spines, 14 or 15.

Description.—Abactinal membrane fairly thick, about as in *epixanthus* and *granulosus*, and marked by myriads of fine interlacing wrinkles, partly due to the underlying granules. In some specimens the membrane has a minutely warty appearance. Even when dried the outlines of the plates are difficult to make out, although their contours are somewhat indicated by the papular pores. The abactinal area is covered uniformly with tiny spaced spiniform granules which are often a little higher than wide. One is reminded more of very short spinelets than of the rounded, hemispherical granules of *A. granulosus.* They are subequal, about the size of the intermediate granules of *granulosus*, and are more closely placed, there being 45 or 50 on an average carinal plate. They are larger than the granules of *lithosorus* and, unlike them, they do not become widely spaced toward the edge of the area. Scattered over the abactinal area are numerous small 2-jawed pedicellariae, higher than in *granulosus.* In the type they have 2 slender, slightly spatulate jaws, very similar to the abactinal pedicellariae of *cristatus*, as figured by Sladen, while in other specimens (as from station 5122) the jaws are truncate and only 1.5 to 2 times as high as broad, and hence having somewhat the same variations as in *cristatus.* Still other examples have the jaws spatulate and intermediate between the slender forceps and the lower bivalve forms. These pedicellariae are not covered by the membrane. Papulae are found all over the disk except a narrow interradial streak, and are absent from a small portion of the end of the ray.

The relation between the primary and secondary abactinal plates is as in *A. granulosus.* On the *proximal* portion of the radial areas the small, irregular plates surround the carinal plates, and the plates of one or more longitudinal series on either side. They gradually become restricted to either side of the carinal series near the middle of R. Beyond about the middle of R there are no secondary plates. The primary plates usually have 6 short lobes or far along ray, are roundish without very evident lobes. On the central part of the disk the lobing is irregular, and near the margin the plates are irregularly 4-lobed or 4-sided.

Superomarginals, 30 in the type, are not at all tumid, and form a slightly arched bevel, the first 5 or 6 slightly wider than long; the succeeding 12 to 14, longer than wide; and the remainder gradually becoming wider than long. They decrease very gradually in width, irrespective of the changing length, and are covered with spaced minute granules, with 5 or 6 spaced coarse hemispherical granules on the center of the first 4 or 5 plates. These are the only granules that show through the membrane, as a rule, although there is variation in this respect. Usually the plates feel smooth to the touch, the granules not being so evident as in *granulosus* or *lithosorus*. This is particularly true of the medium-sized and small specimens. In some of the largest specimens the proximal plates have 1 or 2 small spatulate 2-jawed pedicellariae, but these are present in less than half of the specimens. Terminal plate pentagonal from above, with 5 terminal spines.

Inferomarginals extending laterally slightly beyond the superomarginals, the actinal face wider than long at base of ray, gradually becoming longer than wide at the middle. They are covered with spaced, rather unequal, granules coarsest on the margin (and these about as large as the largest superomarginal granules), decreasing in size toward the inner margin of plate. The plates are narrower than in *lithosorus*, but the granules are of nearly the same relative size, perhaps a little smaller.

The actinal intermediate plates extend to the twelfth inferomarginal or a little over half the length of ray in large specimens, and are covered with spaced, coarse, hemispherical granules, 3 to 10 in the center being the largest, and the others of several smaller sizes, as in *granulosus* and *lithosorus*. A variable number of proximal plates of the series adjacent to the adambulacrals bear 1 or 2, or occasionally as many as 6 forcipiform pedicellariae. In this type these are very few, but a specimen from station 5260 has many. Some examples (as station 5501) have the pedicellariae intermediate between the bivalved and forcipiform types, just as the abactinal pedicellariae vary. In the example from station 5260 the granules on the inner chevron of plates tend to become pointed and spiniform. In the large and small alcoholic specimens the outlines of the actinal intermediate plates are usually visible, but not in the medium-sized examples where, also, the central granules are less prominent than in the largest specimens. In the latter, the central granules appear as spaced clusters overlaid by membrane, the smaller granules being inconspicuous or invisible until dried.

Adambulacral plates similar to those of *granulosus* but more variable as regards the subambulacral armature. Furrow spines stout, compressed, of nearly uniform width when viewed from above, but tapering as regards the other dimensions to a rounded, chisel-like point in the type. They vary a good deal in form. They are generally 4-sided, the transverse diameter being greater than the longitudinal (as regards axis of ray). The type has proximally 7 or 8, and on the outer part of the ray 6 or 7 spines forming a basally webbed, palmate series with a convex distal margin. The number varies to 6 or 7 and 8 or 9 spines proximally in different specimens. At the adoral end of the series is a slender sessile forcipiform pedicellaria as long or nearly as long as the adjacent adoral spine. The pedicellaria viewed from the side has a lanceolate contour and its form is best appreciated from the figure. In the type there are proximally 2 or 3 coarse, tapering, subconical bluntly pointed, sometimes flattened spines, much heavier but shorter than the furrow spines, and forming a longitudinal series. On the outer part of the ray there is 1, or sometimes 2, in a transverse series, varying from blunt clavate to tapering and pointed. At rare intervals a pedicellaria takes the place of a spine. On the proximal half of the furrow, however, it is more usual to have 1 to 3 prominent forcipiform subambulacral pedicellariae either grouped, scattered, or forming a longitudinal series with the nearly constant adoral pedicellaria near the furrow. A few unequal, prominent, conical granules are present, sometimes standing in line with the 1 or more pedicellariae, while the outer part of the plate, as in the type, is occupied by small spaced, sometimes spiniliform, granules.

Mouth plates convex actinally, with 14 or 15 marginal spines, the inner 4 or 5 rather rapidly enlarging and becoming strongly compressed and leaf-like. The type has 6 to 9 suboral tubercles, scattered granules, and a pedicellaria. Most of the specimens have only 2 or 3 tubercles and 2 to 6 pedicellariae, in addition to spaced granules. The suboral armature is very variable.

Madreporic body similar to that of *granulosus*, subcircular, fairly large, with dichotomously branching, radiating ridges, separated by fine slightly sinuous striae.

Anatomical notes.—The intestinal coecum is practically as in *A. cristatus*. There are 5 slender, interradial bifurcate sacs, the distal divisions passing on either side of the membraneous interbrachial septum, to which they are firmly attached. The intestine is very short and slightly eccentric. The gonads are arranged in a compact series of about 10 tufts on either side of and parallel to the interbrachial septum, and extending from about $\frac{1}{3}$ r from center to within about 10 mm. of the marginal plates.

Type.—Cat. No. 30561, U.S.N.M.

Type-locality.—Station 5121, 9 miles southeast of Malabrigo Light, east coast of Mindoro, 108 fathoms, dark green mud; 1 specimen.

Distribution.—East coast of Mindoro to the Mindanao Sea, 214 to 392 fathoms, green mud and ooze; temperature range, 51.4° to 54.3° F.

Specimens examined.—In addition to the type, 13 from the following localities:

Specimens of Anthenoides rugulosus examined.

Station.	Locality.	Depth.	Nature of bottom.	Number.	Bottom temperature.
		Fathoms.			° F.
5122	20 miles southeast Malabrigo Light, east coast of Mindoro.	220	Green mud....	1	....
5198	10 miles northwest Baliscasag Island, western Bohol...	220	.....do........	1	53.9
5260	Off southeastern Mindoro..........................	234	Green mud, sand.	1	51.4
5501	8 miles northwest Macabalan Point Light, Mindanao...	214	Fine gray sand and mud	3	54.3
5503	6.6 miles northwest Macabalan Point Light, Mindanao..	226	Green mud...	5	53.3
5527	Between Siquijor and Bohol Islands................	392	Globigerina ooze.	1	53.3
5536	Between Negros Siquijor Islands....................	279	Green mud....	1	53.5

Remarks.—This species is readily distinguished from *A. granulosus* by its decidedly longer, slenderer rays, narrower supermarginal plates, and the uniform, rather close, and finer granulation under the smoothish abactinal membrane. In *granulosus* the granules of the superomarginal plates are coarse, distributed all over the plate, and show through the membrane, causing the plates to feel rough in alcoholic specimens. In *rugulosus* the granules are fine, like those of the abactinal plates, and only a few central enlarged granules on the first 5 or 6 plates show through the membrane. As a result the superomarginals (with the exception of the central part of the first few plates) are smooth in undried specimens. The abactinal pedicellariae are forceps-shaped and like those of *A. cristatus*. A characteristic of *granulosus* is the larger size of the central granules of each abactinal plate; in *rugulosus* it is to be emphasized that the granules are subequal. *A. lithosorus* differs in having the abactinal granules very numerous in the center of disk, becoming smaller and much sparser toward the margin; in having wider and more tumid superomarginals, which maintain their width to near the end of the ray; in having a coarser actinal granulation, coarser superomarginal granules on central part of the proximal plates and much finer, sparser granulation elsewhere; and in having 9 or 10 furrow spines.

Genus ATELORIAS Fisher.

Atelorias Fisher, 1911*c*, p. 424. Type, *Atelorias anacanthus* Fisher.

Diagnosis.—Goniasteridae with unequal marginals, the superomarginals the larger, conspicuously overhanging the inferomarginals and forming an angular margin to disk and rays; with all the plates granulate and covered with thin soft membrane, leaving each plate distinct; abactinal plates, not elevated, flattish, numerous, extending to tip of ray; papulae in radial petaloid areas; adambulacrals with an angular furrow series of rather short, stout, spinelets and subambulacral granules, actinal interradial areas large; disk large and thin, rays slender. Entrenched small upright two-jawed pedicellariae on abactinal, marginal, actinal intermediate, and adambulacral plates. No specialized spines; the furrow spinelets the only ones present.

ATELORIAS ANACANTHUS Fisher.

Plate 73, fig. 2; plate 74, fig. 3; plate 85, fig. 3; plate 94, figs. 3, 3*a–b*.

Atelorias anacanthus FISHER, 1911, p. 424.

Diagnosis.—Rays 5. R=205 mm., r=43 mm., R=4.76 r; breadth of ray at mid interbrachium, 53 mm., at middle of R, 14 mm. Disk large, thin, with wide interbrachial arcs. Rays very long, slender, thin, with an angular margin formed entirely of superomarginal plates. No specialized spines; all plates covered with hemispherical granules overlaid by a thin membrane which partly or wholly obscures them and fills up the interstices, but which leaves the outlines of plates distinct; small excavate pedicellariae with two jaws slightly higher than wide, and usually with depressions in the membrane into which they fit when open, are present on plates of both surfaces; adambulacral plates with angular furrow margin bearing proximally 10 to 12 and distally 6 to 9 rather short stout spinelets; no subambulacral spines, but numerous immersed granules.

Description.—Abactinal plates numerous, crowded, very slightly convex or flat, hexagonal on papular areas, but elsewhere irregularly hexagonal, pentagonal, squarish, or roundish, and reaching terminal plates. They are not at all tabulate but are sunken in the abactinal integument nearly flush with the surface. On the proximal part of the radial areas a carinal series and about two parallel series on each side can be made out, but elsewhere the plates are not regularly arranged. They are much smaller on the interradial areas and center of disk than on the radial areas, and they decrease in size distad, only a single series reaching the terminal plate. On the outer part of the ray the outlines of the plates are very indistinct. Papulae 5 to 8 about each plate, and inconspicuous, extending only about a fifth the length of ray measured from the interradius. All plates covered with rather small hemispherical granules, overlaid by soft membrane, a rather large carinal plate having 30 to 40. In addition most of the plates bear also a small upright pedicellaria with tapering spatulate jaws, often narrow distally, and a little higher than the width of the base. The granules are quite indistinct and normally are entirely covered by the membrane. On some of the plates of the papular areas the granules are visible, but over all the interradial areas they can not be seen, although the skin is pitted somewhat over the interspaces between the granules. When the membrane is partially dried the granules become visible. In this soft membrane the pedicellariae have depressions for the opened jaws.

When the abactinal integument is cleared, and viewed from the coelomic side the plates are seen to be spaced. In form they are not at all uniform, varying from irregularly roundish to lozenge or ellipical, and the inner end is convex. The outer end flares, being larger than the inner, and of the various forms mentioned above.

Superomarginals, about 80 to a ray, are dorsally conspicuously wider than long, and form a beveled margin, sometimes a trifle arched, to the abactinal surface. They encroach upon the actinal surface about one-half as far as upon the abactinal, and thus form the margin of ray. The convexity of the lateral angle of each plate causes the margin of the ray to appear scalloped, except near the extremity. The plates are closely covered with small granules, similar to those of the abactinal plates, overlaid by soft membrane, so that they are very indistinct, or even invisible. On the proximal half of the ray the dorsal surface of the superomarginals bears 2, or rarely 3, small pedicellariae, similar to those of the abactinal plates, while the ventral surface bears 1; the dorsal surface of the plates of the distal half of ray bears one such pedicellaria.

Inferomarginals very slightly convex proximally, corresponding to superomarginals, but along the middle region of ray not exactly corresponding. First 10 plates slightly wider than long, gradually becoming slightly longer than wide over most of the ray. On the outer fourth of ray the inferomarginals are only a trifle larger than the adambulacrals. The plates are entirely confined to the actinal surface and beyond the interbrachium are only a little wider than the ventral facet of the superomarginals—that part which extends laterally beyond the ventral series. Over a little more than the proximal half of the ray the plates bear, near the outer margin, a small 2-jawed spatulate pedicellaria, and rarely a second elsewhere on the plate. When the animal is viewed from the oral side 3 series of plates occupy the entire width of the surface between the furrow and ambitus, on the outer half of the ray—the adambulacral, inferomarginal, and superomarginal series, the first and last of about the same width, the inferomarginals slightly the widest. The granules increase slightly in size from the outer toward the inner margin and are immersed in membrane, with often the tips protruding.

Actinal interradial areas extensive with numerous irregular slightly convex plates, without regularity of arrangement, and extending in a single series nearly half the length of ray, a second series reaching a little over a fifth. The plates are closely covered with small granules immersed in membrane, the tips of the granules often protruding slightly from the membrane or visible yet covered by membrane. In the former case the granules appear to be embedded in a matrix. A majority of the plates bear 1, sometimes 2 or 3, small spatulate entrenched pedicellariae.

Adambulacral plates slightly longer than wide, with an angular furrow margin, the 2 facets of the apophysis being somewhat variable in length, but the distal always the longer and slightly concave as in *Nymphaster.* Spinelets proximally 10 to 12, distally 6 to 9, rather short, stout, round tipped or truncate, in a crowded series, the longest on the angle, and compressed in a plane transverse to the plate, the others gradually shortening slightly and with flat side to furrow. Actinal surface of plates slightly convex, covered with 20 to 35 granules immersed in membrane. Near or at the inner adoral corner of the plate there is usually a pedicellaria with 2 to 4 variable granuliform jaws. There is no enlarged subambulacral spine on the distal plates. On the outer part of the ray the apophyses of opposite plates tend to meet in the middle of the furrow and to segregate consecutive pairs of tube feet.

Mouth plates very slightly convex, coarsely granulate, the granules being conspicuous; marginal spinlets 16 to 19, robust, increasing in size toward the inner angle, where the spinelets are very strongly compressed, broad, and leaflike. The furrow surface of each plate has a shallow vertical depression for the first tube feet.

Madreporic body one-third minor radius from center; ridges coarse, radiating.

Anatomical notes.—Gonads are arranged in a short series nearly parallel with the *radius* and 7 or 8 mm. therefrom. There are 6 or 7 closely placed tufts in the series examined, and it extends only about 10 mm. The coelomic sacs leave a slight interradial area ventrally and adjacent to margin, lined with very fine fibrous tissue, which more or less occludes the cavity. Tube feet with conspicuous sucking disks.

Type.—Cat. No. 28659, U.S.N.M.

Type-locality.—Station 5655, Gulf of Boni, Celebes, 608 fathoms, gray mud, fine sand, bottom temperature 39.2° F.; 1 specimen.

Distribution.—East coast of Luzon, and the Gulf of Boni, Celebes, 565 to 608 fathoms, green or gray mud.

Specimens examined.—In addition to type, a badly mutilated specimen from station 5460, Lagonoy Gulf, east coast of Luzon, 565 fathoms, green mud.

Remarks.—This curious species is notable for the development of the superomarginal plates at the expense of the inferomarginals. The former define the ambitus, and when the specimen is viewed from below the *ventral* surface of the superomarginals forms a narrow border outside the inferomarginals. The presence of a more or less pulpy membrane covering the granular investment suggests an alliance of this form with *Anthenoides*. An important difference is the fact that in *Anthenoides* and *Stellaster* the membrane covers the animal without reference to the underlying plates, while in *Atelorias* each plate is distinct, the membrane not overlying the sutures.

Family OREASTERIDAE Fisher.

Oreasteridae FISHER, 1911*d*, p. 18 (=*Pentacerotidae*, untenable).

Genus OREASTER Müller and Troschel.

Oreaster MÜLLER and TROSCHEL, 1842, p. 44.
Pentaceros SCHULZE, Betrachtung der versteinerten Seesterne u. ihrer Theile, 1760, p. 50 (not binomial). Many authors.

KEY TO SPECIES HEREIN RECORDED.

a^1. No marginal spines or tubercles; a radial series of very large acorn-shaped tubercles, the primary radial the largest; tubercles with flat, polygonal, granules larger than the other abactinal granules, and usually with a subglobose or conical, bare, knob at summit. In addition to radial tubercles, others are sometimes present interradially------*nodosus*, p. 346.

a^2. Prominent distal superomarginal and inferomarginal spines, and usually a few small inferomarginal spines in interbrachia; abactinal spines very prominent, conical, heavy, and granular (the granules not larger than others), with a prominent bare conical sharp tip; these spines are slenderer and higher (as a rule) than those of *nodosus* and occur radially, interradially, and usually within apical area------------*alveolatus*, p. 348.

OREASTER NODOSUS (Linnaeus).

Plate 102, fig. 2.

Asterias nodosa LINNAEUS, Syst. Nat., ed. 1758, p. 661.
Oreaster nodosus BELL, 1884, p. 70.—CLARK, 1908, p. 280.
Pentaceros turritus PERRIER, 1875, p. 240 (which see for earlier synonymy. Figured by Gray, 1866, pls. 9 and 10, under names *Pentaceros modestus* and *P. franklinii*).

Notes on Philippine specimens.—The specimens vary considerably in the number and form of the large acorn-shaped tubercles of the carinal ridge, as already recorded by Clark.[1] In most cases the tubercles are higher than the breadth at base and are capped by a blunt or pointed tip free from granules. Seven specimens have the tubercle in the center of disk. The maximum number of tubercles is present in specimens from station 5254, where there are 60 in a typical specimen and 69 in another, having in addition to the above 69 dorsal tubercles about 28 smaller superomarginal ones. The tubercle is not always terminated by a blunt or short spine, which is lacking in most of the Pangasinan Island examples. In these the tubercles are covered with granules, which are variable in size, sometimes smaller than at the base, sometimes larger. A few of the tubercles in these specimens may have a blunt spine. The largest primary radial tubercles may terminate in 2 or 3 points. The number of pedicellariae is very variable. They may be very numerous on the dorsal surface or fairly scarce. Their form is also variable; usually the abactinal pedicellariae have slender upright jaws, considerably longer than wide. But in examples from Burias Island the pedicellariae are few and low, with the jaws as low as or lower than broad.

---

[1] See Clark, 1908, p. 280, for variations of specimens from New Guinea.

The furrow spines vary from 6 to 8. The subambularcral spines are usually 3 in number, much heavier than the furrow spines, and grooved or eroded at the tip (as well as down the sides in many large examples). The subambulacral pedicellaria is adoral to the subambulacral spines and between them and the adoral furrow spine. Sometimes this pedicellaria is as long as the median furrow spines, but is ordinarily a little shorter.

One specimen has 4 normal rays and 2 short ones. A specimen from Burias Island has lost all the abactinal tubercles, the scars where they were broken off or torn out are very distinct. Other specimens have lost 1 or more tubercles by accident, the wound having healed.

The most curious variation is exhibited by a specimen from station 5254, which agrees with 2 other examples from that station in all essential respects except the possession of from 1 to 4 superomarginal tubercles on each side of the rays (28 in all). These tubercles are smaller than the dorsal ones. It is possible that this specimen is a hybrid of *O. nodosus* and *O. alveolatus*, a specimen of the latter having been taken in the same haul. The dorsal tubercles are quite typical of *nodosus* and not of *alveolatus*.

It is worthy of note that a series of very small intermarginal plates (4 to 6 to each interbrachium) is present, but completely hidden by granules (see *Pentaceropsis*).

Distribution.—Region of the Indian Ocean, East India Islands (north to Luzon), thence to New Caledonia, in the Pacific.

Specimens examined.—Thirty-four, from the following localities:

San Pascual, Burias Island (off Luzon), tide pool on sand, flat, 6 specimens.

Papatag Island, Tawi Tawi Group, Sulu Archipelago, shore, 3 specimens.

Tataan Pass, Simaluc Island, Tawi Tawi Group, shore, 1 specimen.

Cagayan de Jolo, 1 specimen.

Pangasinan Island, Jolo, reef, 14 specimens.

Pandanon Island, between Cebu and Bohol, coral sand, 1 specimen.

Reef off Cebu, 2 specimens.

Station 5254, Gulf of Davao, Mindanao, 21 fathoms, sand, coral, 3 specimens.

Philippine Islands, Dr. E. A. Mearns, 3 specimens.

OREASTER ALVEOLATUS (Perrier).

Plate 101, fig. 1.

Pentaceros alveolatus PERRIER, 1875, p. 243.—KOEHLER, 1910*a*, p. 95, pl. 10, fig. 1; pl. 14, fig. 7.
Oreaster alveolatus BELL, 1884, p. 73.

Notes on Philippine specimens.—In 2 specimens (stations 5254 and 5141) the spines are absent from the interradial region of the dorsal surface; in the others there are from 5 to 10 spines in each interbrachial area, in addition to those of the midradial line and apical area. The spines are for the most part very prominent, slenderer than the tubercles of *O. nodosus*, and upward of 20 mm. in length. The granules are absent, as a rule, from the tip, which is conical and sharp. Those covering the lower part of the spine are a little larger than the granules covering the plates, crowded, flat, and polygonal. In the largest example, having R=170 mm., 3 of the 5 primary radial spines are double, and there are 3 spines within the apical area. In all the specimens the interbrachial inferomarginal spines are poorly developed, and in an example from station 5141 there is only a single small tubercle in 2 interradii, but 2 to 4 prominent inferomarginal spines at the end of the ray. The superomarginal spines are usually very prominent, especially in a specimen from station 5146, where there are upward of 14 on either side of each ray, most of them ending in a bare, conical sharp point. In 2 interbrachia there is a single superomarginal spine. This specimen has 3 to 5 interbrachial inferomarginal small, blunt, tuberculate spines. The trabeculae separating the papular areas are well marked, except sometimes the transverse ones of the series of areas just above the superomarginals, where the areas may be partly confluent. Along either side of the ray, which is naturally high, are 3 well-marked lines of papular areas, with 1 or 2 additional for a very short distance at the base of ray. The uppermost series may be subdivided into 2 series of alternating triangular areas, while the areas of the 2 lower series are rectangular, elliptical, or irregular.

In addition to long, low, bivalved, slit-like pedicellariae on the trabeculae, there is a very variable number of small upright forceps pedicellariae on the papular areas. The jaws of these vary in height from about the length of the surrounding granules (Jolo) which are subconical or convex, to twice the length (stations 5149, 5254) or a little over.

A specimen from station 5141 has numerous much larger pedicellariae with slender, curved, spatulate jaws about 4 times as high as the granules. These are on the papular areas while the usual slit-like form occupies the trabeculae.

The adambulacral armature does not agree with the description of Perrier. There as 7 or 8 furrow spines (5 or 6 in the type), but in a specimen from station 5254, 9 or 10. Subambulacral spines 2 or 3, heavy, with wrinkled tips. External to these is a second series of 2 or 3 shorter spines, or rather enlarged granules, likewise with slightly wrinkled tips. Perrier speaks of but 1 series of subambulacral spines. These specimens are really triplacanthid according to Bell's classification. The granules of the actinal surface are very unequal in size, some of them being fairly tuberculate.

A young example with R=23 mm. has developed low primary radial spines, several superomarginal spines, and upward of 5 superomarginal spines at the end of ray only. The disk is low and the general appearance goniasterid. A slightly larger specimen has developed a few additional lophial spines. Furrow spines 5 or 6; usually 2 subambulacral spines.

Four to 6 small intermarginal plates are present in each interbrachium. The largest can sometimes be detected, but the smallest are obscured by the granules.

Type-locality.—New Caledonia.

Distribution.—New Caledonia and Philippine Islands.

Specimens examined.—Nine:

Jolo Market, Jolo; 1 specimen.

Station 5136, off Jolo Light, Jolo, 22 fathoms, sand, shells; 1 specimen.

Station 5141, off Jolo Light, Jolo, 29 fathoms, coral sand; 1 specimen.

Station 5146, off Sulade Island, vicinity of Jolo, 24 fathoms, coral sand, shells; 1 specimen.

Station 5149, near Sirun Island, vicinity of Siasi, Sulu Archipelago, 10 fathoms, coral, shells; 1 specimen.

Station 5165, near Observation Island, Tawi Tawi Group, Sulu Archipelago, 9 fathoms, coral; 1 specimen (young).

Station 5253, off Linao Point, Gulf of Davao, Mindanao, 28 fathoms coral; 1 specimen (young).

Station 5254, same locality and depth; 1 specimen.

Mansalay Bay, southeast Mindoro, 5 to 10 fathoms, 1 young.

Remarks.—This species seems to have been known previously only from New Caledonia, where it has a near relative, *O. novae-caledoniae* (Koehler). It is nearest *O. linckii*, to which none of the

Albatross specimens appear to be referable. It is especially characterized by the very prominent, often sharp dorsal spines, together with supero- and inferomarginal spines.

Genus PENTACEROPSIS Sladen.

Pentaceropsis SLADEN, 1889, p. 350. Type, *P. obtusata* [=*Asterias obtusata* Bory de Saint Vincent].

PENTACEROPSIS TYLODERMA Fisher.

Plate 94, figs. 8, 8*a–b*; plate 97, fig. 1; plate 98, fig. 2; plate 100, fig. 1.

Pentaceropsis tyloderma FISHER, 1913*c*, p. 209.

Diagnosis.—Differing from *P. obtusata* in having one series of subambulacral spines, in lacking inferomarginal tubercles, except on the first few plates, in having less prominent distal superomarginals without smooth tubercles, and very much smaller granules among the papulae than on the convex plates. R=94 mm., r=49 mm., R=1.9 r; breadth of ray at base, 44 to 54 mm. Disk inflated, rays convex, much lower than disk; actinal surface subplane; interbrachial arcs well rounded: rays broad, tapering little until near the end, which is rounded.

Description.—Abactinal surface of disk convex or inflated, about half as high as width of ray at base. No true spines anywhere except on the adambulacral and mouth plates. Abactinal surface paved with plates of about 3 sizes, but only 2 of these are evident externally, because the small ossicles which fill in the spaces between the large plates are covered with granules. First the appearance of the abactinal surface before the removal of granules: There is a not very regular carinal series of about 12 convex, transversely elliptical plates, starting with the primary radial, spaced about one-fourth to one-half their longer diameter, which varies from 4 to 7 mm. Between this and the superomarginal series are 3 others, not at all regular, spaced, convex, decreasing in size toward the margin, the adradial plates being transversely elliptical, the others irregularly roundish. Two dorsolateral series reach the end of the ray, the third extends about two-thirds or three-fourths the length of ray, while in the interbrachial arcs are 2 additional series, the plates being rather small and of secondary size. These primary plates are covered with close-set, flat, or very faintly convex polygonal granules, which increase very rapidly in size from the margin toward the center, where 1 to several are conspicuously larger than the rest and slightly more convex. The plates of second size are widely spaced, unequal, and, except near the ambitus, are conspicuously smaller than the primary plates. They are most numerous on the disk and proximal portion of ray, rather few on the outer part of ray. They are convex, and usually bear a relatively large hemispherical tubercle, very much larger than the granules surrounding it.

Between the primary and secondary plates the integument is thickly beset with very small, unequal, convex, subconical, or even spinuliform granules, largest on the center of the small intercalary ossicles and smallest on the margin of the papular pores. Small pedicellariae with spatulate jaws slightly higher than wide, or sometimes wider than high are scattered among the granules, which they exceed little or not at all in size. Papular pores, rather evenly distributed, occupy all this granular area among the primary and secondary plates, even to the tip of ray, and likewise between angular dorsal extensions of the superomarginal plates. There is no subdivision into areas.

If a portion of the dorsal surface is cleared of granules the primary plates are seen to have a scalloped or crenulate margin best marked on the radial series. The secondary plates also usually have 5 to 7 short lobes or indentations on the margin. The intercalary ossicles are of various sizes and forms, often elongate and do not extend to the coelomic side of the body wall. The smaller the ossicle, the more superficial it is. The body wall is very thick (5 or 6 mm.). Only the primary and secondary plates form its entire thickness. Viewed from the coelomic side the plates form regular series in quincunx. The primary plates have, on either side, 2 elliptical slender ossicles which bind each to 2 plates on that side. The plates are subequal and transversely elongate as viewed from the inner side, but the superficial end of alternate plates (or sometimes 2 together) may be of only secondary size, or even be obscured by the intercalary granules. Such are the secondary plates which form longitudinal series with the primary plates. The secondary plates, which are *between* the longitudinal series, abut against the small connecting ossicles of the coelomic side, so that their inner ends are not seen, being obscured or covered by these lateral connecting ossicles.

The arrangement of the abactinal plates is similar to that in the genus *Asterodiscus*, and unlike that of *Oreaster*.

Ambitus bounded by superomarginals, the inferomarginals being actinal. Superomarginals 16 to 18, wider than long, convex, unequal, and triangular in general form, the apex dorsal. The largest plates are near the middle of ray, whence they decrease in size toward either end of the series. The largest are about 7 mm. wide by 4 long, and are covered by polygonal granules similar to those of the dorsal primary plates, largest in center and decreasing rapidly in size toward the periphery. Between the dorsal angular ends of the superomarginals are numerous papulae forming a serrate border to the abactinal papular area. These papulae sometimes extend nearly to the inferomarginal plates. In 1 case there is a small isolated intermarginal papular area with 7 papulae.

The inferomarginal plates are for the most part opposite the superomarginal, but become more numerous at the end of the ray, there being 20 or 21. They are wider than long and oval in form, the narrower end toward the furrow. The plates increase rather rapidly in size up to the middle of the ray, then decrease very gradually to near the end of ray, then rapidly. They are very slightly convex, but plane in the midle and paved with close-set polygonal granules, which increase in size toward the outer margin, without attaining the size of the largest superomarginal granules, except on the first 3 or 4 plates. These plates are smaller than the others, and covered by granules which look as if they had flowed onto the plates from the actinal intermediate area. The outer end of some of the plates bears a low flattened tubercle.

The small intermarginal plates are found both at the base of the ray and irregularly near the tip. The proximal ones, numbering 7 to 10 extend one-third to one-half the length of ray; the outer 3 or 4 of these are isolated. Then, near the end of the ray are 2 to 4 small isolated plates at the corners of the marginals. On one ray the series extends from interradius to near the tip, skipping only 2 marginals twice. There are about 18 plates in this series, some very small. The first 2 or 3 usually have a central flattened tubercle, in addition to polygonal, more or less elevated granules; the others are granular.

Terminal plate small, convex, abactinal in position. It is granular and shows the scar of a small terminal tubercle.

Actinal intermediate plates in series from adambulacrals to margin, the first complete series leaving the fourth adambulacral and meeting first inferomarginal. It abuts against the corresponding series of the adjacent ray at the middle of r. In the angular area thus inclosed, are less regular, more convex plates, the central granules very prominent, and sometimes tubercular. The other plates are slightly convex, and covered with slightly spaced polygonal granules (with rounded corners) 1 or 2 series on the margin of the plates being considerably smaller than the rest. The plates adjacent to adambulacrals extend nearly to tip of ray; the series parallel to this is very irregular, but reaches nearly as far, its plates being separated on outer part of ray by the inner end of the inferomarginals. Rather small, low, beveled pedicellariae are present on the plates adjacent to adambulacrals.

Adambulacral armature like that of *Oreaster*. Furrow spines 8, the 2 central about as long as the slightly curved furrow margin, the others rapidly diminishing in size, the laterals being only one-fourth or one-fifth the length of the mesial. Subambulacral spines 2 (less often 3), becoming 1 near the end of ray. They are stout, flat, as long or longer than extreme width of plate, round tipped or truncate, frequently broader at tip than base, and smooth. The outer edge of plate is bordered by 6 or more small pinched granules, which also extend a variable distance along the transverse margins. A slender slightly curved, 2-jawed, upright pedicellaria stands near the adoral, inner corner of plate, with frequently a second smaller one a short distance back of it, or sometimes near the outer adoral corner.

Mouth plates with 14 to 18 furrow spines the adoral 4 heavy, the rest decreasing very rapidly, the aboral being short. All the smaller spinelets are slender, more or less flattened, and bent toward the mouth angle. Subambulacral spines 5, the 2 series uniting at the inner end and forming a horseshoe-shaped series for each mouth angle. Outer end of mouth plates granular, with numerous pedicellariae, as in *Oreaster*.

Madreporic body large, roughly 4-sided (unsymmetrical lozenge shape), flat, with numerous fine striae. It is at the edge of the apical area, its outer end a little less than $\frac{1}{2}$ r from center.

The color in alcohol is a very deep brown, almost black; the specimen was bleached for photographing.

Type.—Cat. No. 32632, U.S.N.M.

Type-locality.—Tictauan Island, east of Zamboanga, Mindanao.

Distribution.—Known only from type-locality.

Remarks.—*Pentaceropsis tyloderma* differs from *P. obtusata*[1] in having only 1 series of usually 2 (1 to 3) subambulacral spines (not 2 series of 3 to 4 each); slightly more numerous furrow spinelets (8, in *obtusata* 5 to 7); in having larger triangular superomarginal plates, without special tubercles (small, roundish, and with tubercles in *obtusata*). In *obtusata* the abactinal plates which are convex are more numerous and closer together, and the medioradial series is not so clearly distinguishable as in *tyloderma*. The photographic figures will give a better idea of the exact appearance of the creature.

Nearly a year after the original description of *P. tyloderma* was published I saw at the Museum d'Historie Naturelle 7 dried specimens of *P. obtusata* from Mindoro (No. 247875). While I was not able to make a direct comparison with *tyloderma*, even a hasty examination showed me that they belonged to a distinct species. Perrier's notes in the Revision (p. 250) were based largely upon these specimens. A few weeks later I saw 2 specimens of *Pentaceropsis* at the British Museum. One, from Blanch Bay, New Britain (Willey collection) is almost certainly not *obtusata;* neither does it appear to agree well with *tyloderma*, having very small superomarginals, and also a quite different facies from the Paris specimens. A smaller example (No. 399, Cebu, *Challenger*) has been recorded by Sladen (1889, p. 351). This, also, agrees very poorly with the Paris specimens which may be regarded as typical, but as I was unable to make notes from a direct comparison of specimens, any general observations would be uncalled for.

---

[1] Description by Müller and Troschel, 1842, p. 50; Perrier, 1875, p. 250.

Unless *Pentaceropis* is extraordinarily variable there are probably at least 2 forms going by the name of *obtusata*.

Pentaceropsis euphues Sluiter (1895, p. 56) is a small species (R. 26 mm.) with marginal and abactinal spines. It is possibly a young specimen and not a *Pentaceropsis*. The present species is placed in the genus *Pentaceropsis* on account of the presence of a conspicuous intermarginal series of plates and the externally nonreticulate dorsal skeleton. The first character is of doubtful value. Sladen (1889, pp. 343 and 350) gives it primary importance, but intermarginal plates of quite noticeable size are present in large examples of *Oreaster hawaiiensis* and *O. occidentalis* (Fisher, 1906, p. 1073). I find small intermarginal plates (4 to 6 in each interbrachium) in even medium-sized examples of *O. nodosus*, completely obscured by the granulation; still larger ones are present in *O. alveolatus* and *O. mammillatus*, but apparently not in *O. reticulatus*. I have not been able to examine other species, but I have no doubt that the character is widespread in the genus.

Probably the most importance difference between *Oreaster* and *Pentaceropsis* is the structure of the abactinal skeleton, which externally is not reticulate, although internally the short connecting ossicles between the longitudinal rows of primary plates constitute the beginnings of such a structure. The superficial skeleton is composed of very numerous small ossicles closely packed between the conspicuous primary plates, and among the former are numerous papulae not set off into separate areas. The abactinal skeleton is quite similar to that of *Asterodiscus*, although internally the skeleton of the latter is obviously reticulate, having rather long intermediate ossicles arranged stellately between the primary plates, and forming sunken triangular areas.

Genus ASTERODISCUS Gray.

Asterodiscus Gray, 1847*a*, p. 176; 1847*b*, p. 75; 1866, p. 5. Type, *A. elegans* Gray.

KEY TO THE KNOWN SPECIES OF ASTERODISCUS.

a.¹ Abactinal tubercles conical, more or less acute to hemispherical, or truncate hemispherical; R=less than 1.8 r.

b.¹ Only the primary abactinal tubercles with a basal circle of granules; no small granules thickly scattered between the tubercles; inferomarginal plates subequal to superomarginals, the surface with several large granules and a small tubercle; superomarginals abactinal in position, covered with coarse granules; marginal granules of actinal intermediate plates very coarse; four or five furrow spines______________*elegans* Gray, p. 355.

$b.^2$ All the abactinal tubercles with a basal circle of granules; numerous small granules thickly scattered between the tubercles; inferomarginal plates conspicuously smaller than superomarginals, the entire surface occupied by a conical tubercle; superomarginals lateral in position, most of the surface bare; marginal granules of actinal intermediate plates small; six or five furrow spines___________________________*tuberculosus* Fisher.

$a.^2$ Abactinal tubercles obconical to obovate, broader at summit than at base, the surface convex or truncate; R=2 r.

$b.^1$ Superomarginal plates distinguishable, the terminal only moderately large (8 mm. diam.); inferomarginals 9 or 10; abactinal tubercles fewer and very large (6 to 7.5 mm. diam.): actinal intermediate tubercles not large, nor spatulate or flattened, near furrows; furrow spines four; outer subambulacral spine not flattened nor heavier than the inner.
truncatus Coleman.

$b.^2$ Superomarginal plates not distinguishable, the terminal unusually large (13 mm. diam.); inferomarginals about 18; abactinal tubercles, especially the secondaries more numerous, and all smaller (2.5 to 3 mm. diam. for largest); actinal intermediate tubercles larger toward furrow, and spatulate or flattened; furrow spines three; outer subambulacral spine flattened and heavier than inner_____________________*helonotus* Fisher, p. 357.

ASTERODISCUS ELEGANS Gray.

Plate 97, fig. 2; plate 101, fig. 2.

Asterodiscus elegans Gray, 1847*a*, p. 176; 1847*b*, p. 75; 1866, p. 5, pl. 12, figs. 1 and 2.

Notes on Philippine specimens.—The specimens are referred to this species with considerable hesitation, because there is no adequate description of Gray's types, and his figures do not show the side view of the ray which is desirable when the description is so meagre. The specimens are more stellate than Gray's figure; nearly as much as the type of *A. tuberculosus;* e. g., R=36 mm., r=24 mm., R=1.5 r. There are more numerous abactinal tubercles than are represented in Gray's figure, and these are of a low, blunt, conical form, not truncate. A fairly regular carinal series of 11 is present: and alternating with them on either side is a less regular adradial series, with the beginning of a second series near the center of disk. These primary tubercles are surrounded at the base by a ring of convex granules, but the smaller unequal slightly spaced secondary tubercules which cover the rest of the abactinal surface are almost always without the granules at the base, unless the tubercle is nearly as large as the primary ones. Herein lies a conspicuous difference between this species and *A. tuberculosus* Fisher. In the latter all the tubercles are surrounded by bead-like granules, and between the tubercles are many minute granules thickly covering the whole test. These are absent in this specimen of *elegans.* Nearly all the larger tubercles have at the base a pedicellaria with 2 slender curved jaws nearly as long as the tubercle; these are present also beside many of the smaller tubercles.

What appear to be the superomarginal plates are 2 in number (omitting the large distal plate) and are relatively widely separated from the inferomarginals (3 mm.), being actually abactinal in position, and the outer is at the proximal third of ray. They are covered by 4 or 5 tubercles (one larger than the rest) and a circle of tumid granules.

In *A. tuberculosus* the 3 superomarginals are relatively less spaced from the inferomarginals and have a conspicuous bare surface. In *elegans* the superomarginals and the tubercular intermarginal plates may bear a pedicellaria. The terminal superomarginal is broadly oval, less convex, and larger than in *tuberculosus*, its long diameter being 5.5 mm. or about one-fourth the length of ray measured on side. Inferomarginals 9, decreasing regularly in size, covered with coarse granules, with usually a tubercle on the margin. The proximal 4 or 5 are separated by 1 or 2 vertical series of plates. They are about equal in size to the superomarginals, whereas in *A. tuberculosus* the inferomarginals are conspicuously the smaller, and moreover bear a large acorn-shaped tubercle occupying all or nearly all the surface of plate.

The actinal intermediate plates bear 5 to 10 very coarse unequal, convex or tubercular granules, 1 of which is enlarged into a hemispherical or low acorn-shaped tubercle, 1 or 2 of the granules being only slightly smaller. These tubercles are most prominent on the outer half of ray, and near the mouth plates, being smaller interradially. Many of the plates bear a curved slender 2-jawed pedicellaria.

Furrow spines 4, slightly compressed, round-tipped, the adoral slightly shorter than the other 3. Subambulacral spines 2, heavy, round-tipped, in a transverse series, the outer the shorter. The margin of plate is provided with a series of small pinched granules. Marginal mouth spines 8; suboral spines usually 3 in a series parallel to furrow.

The differences between this species and *A. tuberculosus* may be summed up as follows: *tubereulosus* differs from *elegans* in having numerous small granules between the abactinal tubercles, and surrounding not only the primary tubercles, but also the secondary; these granules are smaller and more beadlike; the superomarginal plates are conspicuously larger than the inferomarginal (not subequal), are lateral in position (not abactinal), and are situated nearer to the inferomarginals; they are mostly naked and surrounded by a series of beadlike granules; the inferomarginals, instead of being covered by numerous coarse granules (as in *elegans*), are provided with an acorn-shaped tubercle occupying all the surface of the plate; the terminal superomarginal is more convex and smaller; in *elegans* the actinal intermediate granules or tubercles of each plate are nearer of a size: that is, the marginal granules are very coarse, while in *tuberculosus* they are small. The adambulacral formula of *tuberculosus* is $\frac{6\ (\text{or}\ 5)}{2+1}$ or $\frac{6\ (\text{or}\ 5)}{1+1}$; in *elegans* it is $\frac{4\ (\text{or}\ 5)}{1+1}$. The adambulacral pedicellariae found by Sladen in the *Challenger* specimen of *elegans* do not appear to be present in the *Albatross* specimen.

Type-locality.—Gray states that the locality is unknown, but Perrier (1875, p. 256) records the type as from northeast China.

Distribution.—Philippine Islands and northeast China(?).

Specimens examined.—Station 5181, 3.8 miles southeast Cabugan Grande Island, Surigao Strait, east of Leyte, 61 fathoms, sand, shells, gravel; 1 specimen.

Station 5482, 4.5 miles southeast of Cabugan Grande Island, 67 fathoms, broken shells, sand, green mud; 1 specimen.

ASTERODISCUS HELONOTUS Fisher.

Plate 95, figs. 1, 1*a*; plate 96, figs. 1, 2.

Asterodiscus helonotus Fisher 1913*c*, p. 210.

Diagnosis.—Similar in shape and general appearance to *A. truncatus* Coleman, but differing in having smaller and more numerous abactinal tubercles (of a similar form), much larger terminal superomarginal plate, less conspicuous marginal plates (the superomarginals not distinguishable); more numerous inferomarginal plates, 9 underlying the terminal superomarginal, and others bearing a large, compressed, fan-shaped tubercle; flattened or spatulate actinal intermediate spines near furrow, where they are larger than near margin; only 3 furrow spines; outer subambulacral spine flattened, and heavier than the inner (the reverse in *truncatus*); inner mouth spines shorter than the others. R=98 mm., r=48 mm., R=2 r; breadth of ray at base, about 53 mm.; general form depressed, strongly stellate.

Description.—Abactinal tubercles similar in form to those of *A. truncatus*, but much smaller and much more numerous. Larger tubercles not arranged in evident series, in form resembling inverted truncated cones, the base of the cone being convex, and the truncated end immersed as it were in the plate and surrounded by a circle of small beadlike granules. Packed closely among the largest tubercles are more numerous smaller ones of several sizes, more numerous than in *A. truncatus*. These are clavate, or obovate, more or less irregular in form, and toward the margin of the disk a certain number become slenderer, and take on a more cylindrical form, with a well-rounded summit. The secondary tubercles are all considerably higher than thick and all except the smallest have at least a few inconspicuous granules around the base. The height of an average primary tubercle is 2 to 2.5 mm. and its breadth at the top 2.5 to 3 mm. (in *truncatus* similar measurements of a comparable specimen are 3.5 to 4.5 and 6 to 7.5). Between the tubercles are widely spaced small granules similar to those around the base of the tubercles. Numerous long, very slender, 2-jawed pedicellariae straight or curved at the end stand beside many of the tubercles. Sometimes the tips of the jaws are widened and truncate. Papulae small generally distributed. A peculiarity of the abactinal and to a less extent the actinal tubercles is that they are very deciduous. The specimen appears to have been well hardened, however.

The marginal plates are difficult to differentiate from the others. Eighteen inferomarginals (of which 9 underlie the large terminal superomarginal) can be distinguished, although the 3 or 4 widely spaced proximals are just like the abactinal tubercles. The distal plates are closer together and bear each a compressed, almost fan-shaped tubercle, quite different from the rest. This becomes subconical on the distal half dozen small plates. The papulae extend up to and even between the inferomarginals, so that the superomarginals can not be positively identified. The terminal superomarginal is larger than in any other species, broadly oval, the broad end actinad, and is bordered by a single row of beadlike, elliptical, granules. Although the surface is curved it is not tumid. Major diameter 13 mm., minor diameter, 10.5 to 11 mm. (In a large specimen of *truncatus* the nearly circular terminal superomarginal is 8 mm. in diameter.)

Each actinal intermediate plate has a conspicuous tubercle accompanied by 1 to 3 much smaller tubercular spines of unequal size, and also often a slender 2-jawed pedicellaria such as are common on the abactinal surface. The plates are surrounded by unequal pinched or prismatic granules, with numerous other smaller granules in the shallow depressions between the plates. The large tubercles are globose or obovate, sometimes slightly compressed, near the margin of disk, but increase in length and become decidedly compressed as the furrow is approached. Those bordering the adambulacral plates are strongly compressed and subspatulate, with a truncate or slightly rounded, beveled distal edge. The spines of the next series are not quite so long or so compressed. Usually 1 or 2 slenderer, but conspicuous, spines accompany each of the large spines, while on these inner plates 1 or more of the marginal granules may be considerably enlarged. The series of plates adjacent to adambulacrals reaches about as far distally as the middle of the large superomarginal. The next series does not reach the inner end of the big plate. In all there are about 7 chevrons of plates.

Furrow spines 3, rarely 4, subequal, slender, compressed, tapering slightly, round-tipped, about 1.5 times the length of base line of the comb, and when standing upright reaching about half the length of the inner subambulacral spine. Subambulacal spines 2 (3 on first 2 plates), in an oblique transverse series, the outer conspicuously the larger and situated adorad of the inner. The outer spine is flattened, untapered, with a rounded or truncate tip, and is slenderer than the adjacent spatulate actinal intermediate spines. The inner spine is slenderer and slightly flattened in a plane oblique to furrow. Near the end of ray the inner spine is subspatulate at tip and a little heavier than the outer. Adorad of the inner spine is usually an upright pedicellaria with 2 slender, lanceolate, or narrowly spatulate jaws about as long as the furrow spines. Margin of plate bordered by unequal pinched granules.

Mouth plates narrow, with 7 furrow and 4 heavier suboral spines in a parallel series. The innermost mouth spine of each jaw is shorter than the next spine. The angle pair of spines is therefore less conspicuous than usual in this family.

Madreporic body convex, with fine radiating convoluted striae, situated about two-fifths r from center.

The dorsal skeleton from the coelomic aspect differs from that of *A. truncatus*. In the latter the large primary plates are connected by 2 slender ossicles end to end, the junction resting on a secondary plate. There are 6 of these double ossicles radiating from each plate, and the triangular meshes of the skeleton thus formed are unusually large. In *A. helonotus* the primary plates, with some exceptions, are connected by a single ossicle, longer, however, than 1 of the ossicles in *A. truncatus*. Six of these radiate from each primary plate; the inclosed triangular meshes are smaller than in *A. truncatus*. It has already been pointed out that the primary plates are more numerous in *A. helonotus*.

Type.—Cat. No. 32633, U.S.N.M.

Type-locality.—Station 5149, off Sirun Island, vicinity of Siasi, Sulu Archipelago, 10 fathoms, coral, shells; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—The chief points of difference between this species and *A. truncatus* have been alluded to in the diagnosis. In *truncatus* the abactinal tubercles are much larger, as I have had the opportunity of comparing a small portion of the abactinal surface of *A. truncatus* directly with that of *A. helonotus*, where the secondary tubercles closely fill the interspaces between the primary tubercles. In *truncatus* the secondary are less numerous and leave wider interspaces, and are actually larger than the primary tubercles of *helonotus*. The large size of the terminal superomarginal, as well as the small size of the other superomarginals, appear to be differences of importance. In *A. truncatus* there are 9 or 10 inferomarginals, in *elegans* 9, in *tuberculosus* 9 or 10, but in *helonotus* there are about 18, the distal 9 underlying the large superomarginal. It would seem that the number of inferomarginals is a fairly conservative character and that the greatly increased number in *helonotus* affords a distinguishing feature of great importance. The ray grows not so much by the addition of new marginals as by the interpolation of additional intermarginals between the already existing inferomarginals. In this species the furrow spines reach the smallest number for the genus, the 2 subambulacral spines are unusually long, and the inner, not the outer, is the slenderer.

A. helonotus differs from *elegans* and *tuberculosus* in respect to the form of the abactinal tubercles, the more numerous inferomarginals, larger terminal superemaginals, indistinguishable proximal superomarginals, spatulate and spiniform inner actinal intermediate tubercles, fewer furrow spines, longer subambulacral spines (the inner being the slenderer), and the short angle-spines of the mouth plates. The inferomarginal tubercles of *A. helonotus* are of a compressed flaring form, somewhat fan-shaped, and entirely different from the conical tubercles of *tuberculosus* or *elegans*.

Genus CULCITA Agassiz.

Culcita Agassiz, Mém. soc. sci. nat. Neuchatel, vol. 1, p. 192. Type, *Asterias discoidea* Lamarck=*Asterias schmideliana* Retz.

CULCITA NOVAE-GUINEAE Müller and Troschel.

Culcita novae-guineae Müller and Troschel, 1842, p. 38.

Notes on Philippine specimens.—Of the 4 specimens from station 5136, 1 shows considerable leaning toward variety *plana*. These specimens have not quite such prominent spines on the spaces between the papular areas as the specimen figured by Döderlein (1896, pl. 19, figs. 3, 3*a*), and the ventral side more nearly agrees with his figure 1*a* (same plate) representing variety *plana*. But the spaces between the papular areas are very narrow and the short pointed spines are more numerous than in the specimens of *plana* listed below, and more numerous than in Döderlein's figures of *plana*. Furrow spines 6 or 7. The largest specimen has R, 97 mm.

(Goto has recently published notes and figures of this species and a review of the literature, as well as a very useful key to the species and varieties of the genus. (Goto, 1914, pp. 515-604, pl. 17, figs. 252–262.)

Distribution.—Döderlein gives the distribution of the typical form, Amboina to Samoa. Goto (1914, p. 507) records it from the Ryukyu Archipelago, and I have examined a specimen from Kagoshima.

Japan. The specimens herewith recorded from the Philippine Islands constitute a new record.

Specimens examined.—Six:

Station 5136, off Jolo Light, Jolo, 22 fathoms, sand, shells; 4 specimens.

Tictauan Island, east of Zamboanga, Mindanao; 1 specimen.

Reef opposite Cebu, Cebu; 1 specimen.

CULCITA NOVAE-GUINEAE, Young.

Two specimens of "*Goniodiscus sebae*," the young of *Culcita novae-guineae*, are present in the collection from the following localities:

Tataan, Simaluc Islands, Tawi Tawi Group, Sulu Archipelago; 1 specimen.

Sablayan Bay, Mindoro, 1 specimen.

CULCITA NOVAE-GUINEAE PLANA Hartlaub.

Culcita plana HARTLAUB, 1892, pp. 74 and 84.

Notes on Philippine specimens.—In respect to the size of the papular areas and the breadth of the interpapular spaces some of these specimens approach very closely the variety *arenosa* Perrier. The ventral surface is almost exactly like that figured by Döderlein for *plana* (1896, pl. 19, fig. 1*a*). A peculiarity of these specimens is the fact that the spaces between the papular areas are almost wholly without spines, but are covered with a very fine uniform granulation, among which are minute 2-jawed pedicellariae, a little larger to twice as large as the granules. In the roundish papular areas, which frequently touch, are unequally spaced rather few short conical spinelets, surrounded by granules slightly larger (or at least longer) than those of the interpapular areas. On the margin, which is high, there are usually a very few widely spaced short conical spinelets on the interpapular spaces, but these are lacking on the dorsal surface, except in a very large specimen from Cataingan Bay, Masbate. Here the spinelets are small and very widely spaced, and absent from a part of the disk.

Distribution.—Döderlein gives Sumatra to Samoa as the distribution of this form; Hartlaub gives Samoa, Viti, New Guinea, Philippines, Amboina, and Mauritius.

Specimens examined.—Four:

Station 5145, off Jolo Light, Jolo, 23 fathoms, coral sand, shells; 2 specimens.

Station 5160, off Tinakta Island, Tawi Tawi Group, Sulu Archipelago, 12 fathoms, sand; 1 specimen.

Cataingan Bay, Masbate, 1 specimen (R=130 mm.).

Genus HALITYLE Fisher.

Halityle FISHER, 1913*c*, p. 211. Type, *Halityle regularis* FISHER.
Culcitaster H. L. CLARK, 1915, p. 144. Type, *Culcitaster anamesus* Clark.

Diagnosis.—Differing from *Culcita* in having the marginal plates visible in the adult, and in having the papulae in very numerous, regularly arranged triangular areas, resembling those of *Oreaster*, usually in sixes around each primary plate; in having regularly tessellated actinal intermediate areas. Form pentagonal, or pentagonal-stellate with very short rays; no spines on any plates except the adambulacral and mouth plates; bivalved and spatulate pedicellariae present; end of rays permanently recurved so that the ambulacral furrow becomes dorsal at the apex.

Remarks.—The type-species is of large size and has retained the phanerozoniate character of young *Culcita*. This feature and the regularly arranged, triangular papular areas generally in sixes, and the very conspicuously, regularly tessellated actinal surface provide a combination of characters not duplicated in either *Culcita* or *Oreaster*.

I think there is little doubt that *Culcitaster* Clark will have to be merged with *Halityle*. The type is from the coast of West Australia. It has short rays at the corners of the swollen disproportionately large disk. The regular arrangement of the abactinal plates and papular areas, and the tessellation of the actinal surface are the same as in *H. regularis*. One important difference, however, is that the marginal plates are concealed except on the terminal third of the ray. Whether this is of generic value can not now be determined.

I agree with Doctor Clark that it is difficult to understand how so large and conspicuous a form should have so long remained undescribed, and like him I have been unable to find anything in the literature which would indicate that European zoologists had ever seen either species.

As Doctor Clark states, the genus appears to occupy a place between *Oreaster* and *Culcita*.

The names *Randasia* Gray, *Goniodiscus* Müller and Troschel, and *Goniodiscides* Fisher (for *Goniodiscus*, untenable), do not enter into competition with *Halityle*, having been founded upon immature specimens of *Culcita*.

HALITYLE REGULARIS Fisher.

Plate 94, figs. 7, 7*a*; plate 95, fig. 10; plate 98, fig. 1; plate 99, figs. 1, 2; plate 100, figs. 1, 2.

Halityle regularis FISHER, 1913*c*, p. 211.

Diagnosis.—Differing from the species of *Culcita* in having well-defined marginal plates in the fully adult, no tubercles or spines on abactinal or actinal plates, and in having more numerous abactinal plates, forming a very regular triangular reticulum, between which are triangular papular areas arranged in regular series parallel to the radial series of plates, and much more numerous than in *C. schmideliana* or *C. novae-guineae*, or their varieties; R=133 mm., r=95 mm., R=1.4 r; form massive, pentagonal with slightly arcuate sides which are perpendicular and formed by the marginal plates and about 1 series of adjacent large papular areas with intervening perpendicular trabeculae (each of which joins the upper end of a superomarginal plate); abactinal surface more or less swollen, and marked off into regular triangular papular areas by narrow trabeculae; whole surface finely granular with minute 2-jawed granuliform pedicellariae; no spines; actinal intermediate plates sharply marked off by sutural grooves and covered with a close mosaic of unequal, smooth, very compact granules; the 3 chevrons nearest furrow with an odd interradial plate, the others without; furrow comb compact, perpendicular, with 8 to 11 slender spines, the aboral end of 1 comb slightly overlapping the adoral end of the next younger comb.

Description.—No spines on any plates except the adambulacral. Abactinal surface, which is variably inflated, marked off into very regular triangular papular areas, grouped in hexagons, the center of each of which is a primary plate, the diagonals (separating the 6 triangles of each hexagon) being the slender connecting ossicles or trabeculae. The primary plates are arranged in quincunx in very regular series parallel to the median radial, on either side of which 3 series can be plainly seen (especially if specimen is dry), with 2 more in the angle made by the interradial line (which is marked by a definite series of ossicles and connectives) and the marginal plates. These last 2 rows are not so regular. At the center of disk the primary radial and basal plates mark off a stellato-pentagonal apical area, within which is a cycle or pentagon of 10 plates, inclosing another of 5 plates, the center of the latter being occupied by the central plate, and one of its sides by the anal aperture. These plates are all connected by regular trabeculae. Between each row of primary plates is a double row of the triangular papular areas containing 50 to 70 pores (sometimes less in small areas). The areas just above the superomarginal plates are larger than the rest, containing upward of 150 pores, and instead of being triangular are roughly lozenge shape or (transversely) elliptical. The trabeculae are covered with very small, crowded, polygonal, unequal, or subequal granules, slightly convex in alcoholic specimens, strongly convex to subconical when dried. On the papular areas the granules are slenderer and longer, in the form of tapering minute spinelets (when specimen is dry). In alcoholic specimens they appear very similar to the interpapular granules. Several very small 2-jawed slender spatulate pedicellariae as long as to twice as long as the granules, are present in each papular area. In alcoholic specimens they are very inconspicuous.

The abactinal body-wall is about 5 mm. thick on the edge of the apical area, radially; in *C. novae-guineae* it is about twice that. The primary abactinal plates are about half as large and twice as numerous as those of *C. novae-guineae.* In the latter there are 6 or 7 primary plates in the radial series between middle of disk and end of ray: in *Halityle* there are 13 in a comparable specimen. As seen from the coelomic side the primary plates are slightly wider than long, with 6 lobes, the longitudinally directed ones being well-developed (poorly developed or absent in specimen of *novae-guineae* examined). They are slightly slenderer than the lateral lobes. The connecting ossicles are slender and strongly overlap the lobes of the primary plates, being dorsal to them. As viewed from above in a cleared specimen these connecting pieces form a very regular triangular network. Within the apical area certain plates have 7 or 8 radiating trabeculae. Embedded in the integument of the papular areas are numerous calcareous granules, many of which have a central pit for a pedicellaria.

Marginal plates plainly visible, the inferomarginals the larger, both sets defining ambitus and perpendicular in orientation. Superomarginals, slightly to not at all convex, roughly triangular, the base against the upper end of the corresponding inferomarginal, and the height greater than the length. Between the tapering sides of the superomarginals are the large papular areas above mentioned. There are about 22 plates to a side. The end of the ray or rather corner of the disk is turned upward, as usual in *Culcita*, and the last 4 or 5 plates are all differently formed; the fifth from end is rather oblong and oriented obliquely; the fourth is unequally triangular; the third elliptical, oriented long way to furrow and abruptly smaller; the second irregularly oblong; while the first plate usually forms a yoke over the abactinal surface just behind the small terminal plate; sometimes this half ring is split into 2 plates. The normal condition, which is certainly exceptional among starfishes, is the yoke form, the plate being common to 2 superomarginal series.

Inferomarginals are more nearly rectangular, but the lower end is rounded. They correspond to the superomarginals as far as about the sixth plate from interradial line, beyond which they are more numerous, there being 40 to the side. Those corresponding to last 4 superomarginals (11 or 12 in number) are transversely oblong and fairly regular, decreasing rapidly in size to the end of ray. Actinal intermediate plates impinge upon the lateral wall of disk between the lower ends of the proximal inferomarginal plates. Marginal plates covered with close, fine, unequal, polygonal granules, the superomarginal a trifle larger than the abactinal, these increasing in size toward the middle of the inferomarginals where the granules are conspicuously larger, irregularly polygonal, and similar to those of the actinal intermediate plates. Minute 2-jawed pedicellariae, as a rule smaller than the granules, are scattered over the inferomarginal plates and very sparingly on the superomarginals (sometimes none). The surface of the plates is smooth in alcoholic specimens, the pedicellariae being sunk in shallow pits.

Actinal intermediate plates, very clearly outlined by furrows, there being 3 regular chevrons of oblong plates (long axis transverse) with an odd plate at apex, followed by about 6 less regular chevrons of elongate hexagonal plates without an unpaired interradial plate. The distal plates of each series are less regular and are situated on the rounded angle between ventral and lateral surfaces. The plates adjacent to furrow are the largest and generally oblong, although the external side may have 2 facets. The intermediate plates also form fairly regular series from the adambulacrals to the margin. The plates are covered with flat, unequal, irregularly polygonal, close-set granules, the middle of the plate being plane, but curving down abruptly at the margins, to the conspicuous sutural furrows. The plates near the mouth angle are surrounded by a fold of the integument, as if by a frame, on which the granules are nearly uniform in size, quadrate and not so closely packed as on the plate proper where they are larger and very unequal. Two-jawed, slightly sunken, pedicellariae, about the size of the quadrate granules, are plentiful around the edges of the plates near the furrow, and smaller ones on the surface of the other plates, especially on the rounded edge of the disk, adjacent to the inferomarginals. There are no signs of tubercles, the granules being very flat and smooth.

Adambulacral plates with a compact straight perpendicular furrow comb of 8 to 11 slender, blunt spines, the adoral the shorter, and the longest slightly aborad of the middle of the series, whence the spines decrease slightly in length to the aboral end of the series. When there are 8 spines they are of nearly equal length, and the first and last of the series are conspicuously broader than the others. The longest spines are slightly longer than the base line of the comb. Back of these are 2 or 3 short heavy tubercular spines (near tip of ray only 1) with rounded, wrinkled or eroded tips. The median is usually slightly the larger when there are 3; and when there are 2 they are subequal, or the adoral is slightly the larger. A large

2-jawed broadly lanceolate pedicellaria often stands at the adoral end of the subambulacral series. The outer margin of plate, just back of the subambulacral series, is occupied by low granules with frequently a pedicellaria composed of 2 stout subconical, granuliform jaws.

Mouth spines 12 to 15, the inner the heaviest, the outer a little larger than adjacent adambulacral spines; suboral spines swollen and wrinkled at tip, 4 or 5 to each plate, in a series parallel to subambulacrals. Back of these 1 to 5 enlarged granules may be present, representing a second suboral series. The outer part of the plates is covered with mostly irregular 4-sided granules, continuous with those of adambulacrals, and also those forming a zone around the proximal actinal intermediate plates. Sutures of mouth plates not visible.

Madreporic body ovate, flat or slightly concave, with numerous fine radiating striae, situated one-fourth the distance from center to suture between superomarginal and inferomarginal plates.

Color in life, maroon red on ventral surface; darker on dorsal surface.

Gonads in numerous tufts parallel to interradius; the hepatic coeca are relatively small, and each is situated close to the interbrachial septum.

Type.—Cat. No. 32634, U.S.N.M.

Type-locality.—Station 5165, 6.4 miles southeast of Observation Island, Tawi Tawi Group, Sulu Archipelago, 9 fathoms, coral; 2 specimens.

Distribution.—Known only from the type-locality.

Specimens examined.—Three; besides the type, one without locality.

Remarks.—*Halityle regularis* will not be readily confused with any known species of *Culcita*. Döderlein in his revision of *Culcita* (1896, p. 315) reduced the number of species to 5, namely *schmideliana*, *novae-guineae*, *grex*, *coriacea*, and *veneris*. The last two may be eliminated, as they have the papulae uniformly distributed over the dorsal surface. The first 3 species have small spines or tubercles on either the papular areas, or interpapular areas, or both. All the species have the marginal plates obscured, except when young. In *H. regularis*, on the contrary, the marginal plates are distinctly visible, although not especially conspicuous, there are no spines or tubercles on the abactinal, marginal, or actinal intermediate plates, and the papulae are in very regularly arranged triangular areas, resembling those of *Oreaster*. The actinal plates are conspicuously tessellated.

Genus CHORIASTER Lütken.

Choriaster Lütken, Catalog des Museum Godeffroy, 1869, No. 4, p. 35. (Also 1871, p. 243.)

CHORIASTER GRANULATUS Lütken.

Choriaster granulatus Lütken, Cat. Mus. Godeffroy, No. 4, p. 35, 1871, p. 243.—Goto, 1914, p. 604, pl. 17, fig. 263; pl. 18, figs. 264–269.

Specimen examined.—Togian Bay, Togian Island, Gulf of Tomini, Celebes, Dutch East Indies.

Distribution.—Pelew and Fiji Islands; off Zamboanga, Mindanao; Celebes; New Zealand; Okinawa Island, Japan (Goto).

Remarks.—This specimen constitutes a new record for the species. R=90 mm., r=35 to 37 mm. Furrow spines 7 or 8; subambulcral spines 3 or 4, rarely 5, in a single series, followed a curved series of granules, inclosing sometimes 1 to several small granules and 1 or 2 small upright 2-jawed pedicellariae. A large 2-jawed lanceolate pedicellaria stands at the inner end of the subambulacral series.

Goto has published (1914) a description of this species, with figures, and has given also a useful reprint of the literature referring to it.

Family LINCKIIDAE Perrier.[1]

Genus DISSOGENES Fisher.

Dissogenes Fisher, 1913*c*, p. 212. Type, D. *styracia* Fisher.

Diagnosis.—Disk large, slightly inflated; rays moderately long and slender; whole body covered with small granules obscuring the outlines of all plates except the marginal, which are confined to side wall of body, and are unarmed except for 1 to 3 small central spines on the first 2 or 3 superomarginals; abactinal plates of 2 kinds, irregular mostly convex primary plates with 2 to 4 semicircular excavations in margin overlying and bound together by secondary elliptical or oblong connecting ossicles, all very irregular in arrangement; primary plates of disk with small rigid central upright truncate spine; actinal intermediate areas with about 4 chevrons of similar longer spines; actinal intermediate plates extending in a single series nearly to end of ray, and a second series two-thirds the length of ray; adambulacral armature with 4 or 5, sometimes 3, prominent slender furrow spines on a nearly straight furrow margin; subambulacral spines 2 on disk, 1 on rays, a little longer and much stouter than furrow spines. Papulae single, irregular, abactinal.

---

[1] For a synopsis of genera see Fisher, 1911*d*, p. 241. As here pointed out, Ophidiasteridae is the oldest name for the family, but Perrier's shorter name has been used by everyone since 1875, including Verrill until 1914 (Verrill, 1914*a*, p. 308). As strict priority is not insisted upon in family names, I see little utility in changing such a well-known and long-used name.

DISSOGENES STYRACIA Fisher.

Plate 102, fig. 1; plate 103, fig. 1; plate 131, figs. 1, 1*a*–1*b*.

Dissogenes styracia FISHER, 1913*c*, p. 212.

Diagnosis.—Disk large, somewhat inflated; rays moderately long, narrow, tapering at first rapidly then gradually to pointed extremity; interbrachial arcs wide, rounded. R=110 mm., r=28 mm., R=4 r; breadth of ray at base, about 34 mm. Marginal plates small confined to side of ray, unarmed except for a small central spine on the first 2 or 3. Body overlaid by a close granulation obscuring outlines of all plates except marginals; abactinal plates irregularly lobed, irregular in arrangement and connected irregularly by smaller secondary plates; primary plates of disk and basal part of ray convex with a central rigid, short, stout, subtruncate tubercular spine; about 4 chevrons of similar longer spines on actinal interradial areas (not reaching margin); furrow spines slender, rather long, 4 or 5 proximally, 4 over most of ray; subambulacral spines heavier, subtruncate, 2 on disk and 1 on ray. Papulae single, all over disk and far along ray, numerous but irregular in arrangement; no pedicellariae.

Description.—Abactinal plates of disk convex, the convexity diminishing on the ray, the distal plates being nearly flat. The plates are strongly overlapping, without order (even the carinal series being irregular) and are covered with closely placed small, irregularly polygonal to subcircular granules which obscure completely the sutures. Many of the plates of disk and proximal fifth of ray bear a central robust slightly tapering round-tipped tubercular spine 1.5 mm. long. These spines are arranged in an irregular carinal series and 3 or 4 subparallel series on either side. On some of the spiniferous plates the granules decrease slightly in size near the base of the spine, while on the edge of the spiniferous area a few plates bear low thimble-form tubercles. Near the end of ray a number of plates have a small central naked area. The papulae extend to within about 25 mm. of the end of ray. They are irregularly distributed and on the outer part of ray tend to form lines of 2 to 4, outlining the larger plates; on the disk and proximal part of ray they are single, spaced, and surround the large and small plates irregularly. Some or all of the granules immediately bordering papular pores are smaller than the others.

The abactinal plates when denuded of granules are seen to be of 2 kinds. Larger irregular plates overlie smaller irregular connecting plates. The 2 kinds intergrade in size. The former are slightly to markedly convex and have 2 to 5 semicircular excavations in the margin bordering papular apertures. The smaller connecting plates as seen from the coelomic side are either oblong, irregularly elliptical, or irregularly triradiate in form. The latter seem to develop into primary plates.

Marginal plates forming a rounded border to each surface, the sides of ray being perpendicular. Marginal plates confined nearly wholly to side wall, encroaching very little upon either surface except in the interbrachial arc where the superomarginals form a narrow border. The plates of the 2 series are nearly opposite, except near tip of ray. Superomarginals 41, the first 3 wider than long, the others a little longer than wide, the adoral transverse margin sometimes slightly curved (convexity adorad), and the other transverse margin correspondingly concave. About the last dozen plates have a naked central area which increases in size distad, the last 3 or 4 plates having only a marginal series of granules. The plates otherwise are covered with granules similar to those of dorsal surface, which decrease in size toward the center of plate; largest granules on transverse sutures. The first 2 or 3 plates bear 1 to 3 small thimble-shaped tubercles, smaller than abactinal spines. The inferomarginals are similar to the superomarginals, but are a little narrower, the last 17 or 18 having a central naked area. The interbrachial inferomarginals are not tuberculate (only 1 plate an exception in type). Terminal plate nearly pear-shaped, small end distal, and with a small terminal cylindrical spine.

Actinal intermediate areas rather extensive and covered with granules slightly coarser than those of abactinal and marginal plates (except marginal granules of latter) becoming more spaced and slightly higher toward the furrow and mouth angle, where the plates bear each 1 or sometimes 2 terete, slightly tapering, truncate, or round-tipped spines, 2 to 2.5 mm. long. There are 45 to 55 spines in each actinal interradial area and those adjacent to adambulacrals extend about one-third the length of furrow; the spines are in about 4 chevrons, and the outer spine on the interradial line is about two-thirds r from center. One series of plates reaches to within 10 inferomarginals of tip of ray; a second series about two-thirds length of ray; a third series one-third; while in the interbrachium numerous additional small plates are wedged in irregularly. In general the outlines of the plates are invisible.

Furrow narrow. Adambulacral plates longer than wide, with a nearly straight furrow margin bearing proximally 4 or 5, but over most of ray 4 (sometimes 3) rather long (2.5 mm.) subterete or very slightly compressed, truncate spines, the adoral slightly shorter as a rule than the other 3, which are subequal. On the first 7 to 12 plates are 2 slightly longer but much heavier, truncate, slightly tapering and slightly compressed subambulacral spines in a longitudinal series just back of the furrow series. The adoral is usually the smaller after the first few plates, which may have a third much shorter adoral spinule. The other plates have 1 subambulacral a little larger than the proximal. A few plates irregularly near end of ray have 2 spines in a transverse series. The first plate has 3 or 4 full-sized spines. The surface of the plate external to the subambulacrals is covered with granules uniform with those of the adjacent actinal intermediate plates, obscuring completely the external suture of the plates.

Mouth plates small with a straight furrow margin bearing 10 furrow spines. Suboral spines 4 to 6 in about 2 series parallel to furrow. Outer part of plate with spaced granules, 8 to 10 in number.

Madreporic body circular, flattish, medium-sized, with fine undulating, branched, radiating striae; its inner edge is about one-third r from center.

Color in life, abactinal surface scarlet, tips of arms pale buff; spines pale; actinal surface pale buff.

No superambulacral plates; ampullae double; tube feet with strong sucking disks.

Type.—Cat. No. 32635, U.S.N.M.

Type-locality.—Station 5617, off Ternate Island, west of Gillolo Island, Molucca Islands, 131 fathoms, bottom not recorded; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—This genus, like *Narcissia* and *Ferdina*, might reasonably be included in the Goniasteridae. It is placed in the Linckiidae on account of the irregular abactinal skeleton, small marginals, and the close granulation which covers the body and obscures the outlines of the actinal and abactinal plates, and on account of the general appearance.

The long, slender, furrow spines and prominent subambulacral spines are unlike those of any other genus of Linckiidae, while the abactinal and actinal intermediate spines are exceptional, and without parallel in any of the Linckiidae having a large disk.

Metrodira, which I have placed provisionally in a special family, has a smooth skin, much smaller disk, and an altogether different adambulacral armature. That of *Dissogenes* is essentially goniasterid.

The genus is not closely related to any other, and the fact that it shows affinities to two families has suggested the name, which signifies a two-fold descent.

Genus FERDINA Gray.

Ferdina Gray, 1840, p. 282. Type, *F. flavescens* Gray.

FERDINA GLYPTODISCA Fisher.

Plate 56, fig. 5; plate 95, figs. 4, 4*a–b*; plate 104, fig. 2; plate 106, fig. 4.

Ferdina glyptodisca Fisher, 1913*c*, p. 213.

Diagnosis.—Resembling *F. offreti* Koehler; differing in having all the prominent abactinal plates, and all the marginal plates with an extensive, central, naked area; the smaller abactinal plates less distinct and not at all convex; granules smallest on center of obscured plates, largest over the sutures (reverse in *offreti*); abactinal area narrower, about equal to extreme width of first superomarginal plate; inner series of small actinal intermediate plates lacking; adambulacral spines 3 (2 in *offreti*). Rays 5; R=35 mm., r=11 mm., R=3.2 r.; breath of ray at base, 13 mm. Rays and disk very rigid; abactinal surface subplane, actinal surface convex.

Description.—Abactinal plates of two kinds: Large, subcircular, convex, numerously lobed and centrally bare plates, interspersed with numerous small, flat, irregular plates covered with a fine close granulation obscuring their outlines. The granules become smaller toward the center of the obscured plates. The large plates, with conspicuous bare areas, comprise five primary interradials, a group of 3 or 4 at the base of the ray (including the primary radial) and, extending along the ray, a series of groups, rather than a series of plates. Each little group has 2 to 4 plates, the groups being sometimes isolated, sometimes connected by large plates so as to form an irregular carinal series. The distal 4 or 5 plates are sometimes separated by small plates. The last three superomarginals meet medially. The width of the abactinal area at base of ray is only about that of the first superomarginal plate. The naked areas on the plates are subcircular to broadly elliptical, quite smooth, and the granules decrease slightly in size toward the edge of this bare area, which comprises most of the area of the plate. Papulae single, and varying in number from 3 to 10 about each plate.

Superomarginals 9, prominent, slightly convex, encroaching widely upon actinal surface, the first, eighth, and ninth wider than long, the others longer than wide; all with nearly the whole surface bare, and with the margin toward the abactinal plates strongly arched and (when cleaned) notched by papular pores. The fine granulation covering the margin of the plates is continuous and similar to that of the abactinal surface. Terminal plate small, subconical, with a row of little tubercles along either side of the end of the furrow.

Inferomarginals much smaller than superomarginals, but corresponding to them. The first is wider than long, the rest longer than wide, except the last or last two, which are subcircular and convex. The third, fourth, and fifth are the longest being 2 to 2½ times as long as wide. Each plate has an elliptical central naked area. This is very slightly concave on the first 5 plates, but there appears in the middle of the fifth or sixth a slight pimplelike eminence which increases in size toward the end of ray and on the last 3 or 4 plates bears one to several low granules. On the plate where the eminence first appears there is no granule. With the exception of the last 3 the inferomarginals are not at all tumid.

Actinal intermediate plates squarish, slightly tumid. The series adjacent to adambulacrals extends to within about 3 inferomarginals of end of ray; a second row extends to the beginning of the sixth inferomarginal; a third row to the beginning of the fourth inferomarginal, while the beginning of a fourth row is present in the interbrachial arc. The plates are not uniform in size but tend to become larger and convex opposite the transverse sutures of the inferomarginal series. Granulation uniform with that of abactinal surface, largest on the sutures and decreasing in size toward middle of plate. It is very close and covers the adambulacral plates also, rising on the outer side of the adambulacral spines nearly to their tip.

Adambulacral plates slightly wider than long, about 15 corresponding to the first 10 actinal intermediate plates of the inner series. Adambulacral spinelets truncate, slightly flattened, in a single series on the edge of the furrow. Each plate has 3, or near the end of ray, 2 spines, but there is no break in the series. Ambulacral furrow closed.

Madreporic body small, elliptical, resembling in miniature half a peach stone.

Color in alcohol, light brownish, the granules encircling the bare areas and the center of small abactinal plates whitish, elsewhere dull orange, especially on disk; actinally the orange hue is duller. The naked areas are light yellowish brown, sometimes with a dark center.

Type.—Cat. No. 32636, U.S.N.M.

Type-locality.—Station 5640, Buton Strait, Celebes (1 mile west of Labuan Blanda Island), 24 fathoms, sand, broken shells; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—Although this species resembles *F. offreti* (Ceylon and Andaman Islands) in the prominent superomarginal and abactinal plates, the resemblance is general only. A very important difference is the absence in *glyptodisca* of a series of small actinal intermediate plates subequal to the adambulacrals, which in *offreti* reach the extremity of the ray, and are only about half as large as the second series. In *glyptodisca* all the prominent abactinal plates and all the marginals of both series are naked centrally, and the small abactinal plates are much less tumid. The granules of the central part of the covered plates are larger, in *offreti*, than those near the margin, while in *glyptodisca* the reverse is the case. A comparison of figures will show that the superomarginals of *glyptodisca* are much larger in proportion to the width of ray, and the abactinal area much narrower than in *offreti*. Finally, *offreti* has 2 adambulacral spines while *glyptodisca* has 3.

Fromia cancellata Grube (Fiji Islands, according to Sladen) has a very characteristic appearance. The rays are broader than in *glyptodisca* and each has 6 regular spaced transverse series of centrally bare plates. The superomarginal plates are alternately large and small, the latter being wholly granulated, the former only about the periphery. The larger plates correspond to the interval between the transverse series of tumid plates.

Fromia kuhlii Müller and Troschel (Java) is insufficiently described. The abactinal plates are small, and irregular as to form and arrangement. Among them are larger, more convex isolated plates naked centrally. The marginal plates are large, and presumably covered with granules. The relation of R to r is as 5 to 1, hence the ray is longer than in *glyptodisca*.

Genus FROMIA Gray.

Fromia Gray, 1840, p. 286. Type, *F. milleporella* (Lamarck).

KEY TO THE SPECIES OF FROMIA HEREIN DESCRIBED.

*a*¹. Superomarginal plates of distal half of ray large and small alternating; granules surrounding papular pores, larger than the others. *japonica*, p. 373.

*a*². Superomarginal plates not large and small, alternating.

  *b*¹. Abactinal plates of proximal half or two-thirds of ray in regular longitudinal series; marginal plates very regular, most of them longer than wide; rays slender; furrow spines 2 or 3, subambulacral spines 2; actinal pedicellariae ---------------------------------- *eusticha*, p. 375.

  *b*². Abactinal plates not in regular series.

    *c*¹. Most of the marginal plates with 1 or more central enlarged tubercular granules; rays slender, about 3 times as long as width at base. *hemiopla*, p. 377.

    *c*². Marginal plates without central tubercles; rays usually about 2 to 2½ times as long as width at base ------------------ *milleporella*, p. 378.

FROMIA JAPONICA Perrier.

Plate 105, fig. 4; plate 106, fig. 2; plate 107, figs. 1, 7.

Fromia japonica Perrier, 1881, p. 14; 1884, p. 227, pl. 4, fig. 2 (Japan).—De Loriol, 1891, p. 31 (New Caledonia).

Fromia major Koehler, 1895, p. 339, pl. 9, figs. 3 and 4; 1910*a*, p. 140; 1910*b*, p. 283, pl. 15, fig. 7, pl. 16, figs. 6 and 7.

Notes on Philippine specimens.—Through the kindness of Dr. H. L. Clark I have been able to examine the type of Perrier's *Fromia japonica*, No. 743, Museum of Comparative Zoölogy, and have compared it directly with the specimen from station 5159. The type of Koehler's *Fromia major* is considerably larger. The major radius measures 55 mm., while that of the type of *japonica* is 32 mm. I do not think the two forms are specifically distinct. The slight differences which may seem apparent from a comparison of the figures and descriptions are more than covered by the variations shown by the 2 Philippine examples. Doctor Koehler does not compare *major* with *japonica* in the references given above.

The example from station 5251 is remarkable for having numerous actinal pedicellariae (resembling split granules with from 2 to 4 jaws) from 3 to 6 times the diameter of the actinal granules. These are largest and most numerous in the actinal interradial areas and extend about half the length of the ray, being found on the actinal intermediate plates, with a very few also on the proximal inferomarginals. There are 2, 3, or 4 furrow spines in this specimen and 2 subambulacral spines (often 3 proximally). When there are 3 the middle spine is the longest, and when there are 2 usually the aboral is the longer. For the distance of about 6 inferomarginals from the end of ray only 1 subambulacral reaches any size. The outer edge of the plate is occupied by 1 (or occasionally 2) series of 4 to 6 granules, or granules and pedicellariae, the former being uniform in size with the actinal granulation (pl. 92, fig. 2).

In the specimen from station 5159 there are 3 furrow spines at the base of the ray, then either 2 or 3, and finally only 2 on the outer half or third of the ray. There are usually 2 subambulacral spines, the adoral a trifle the larger, but near the end of the ray frequently only 1 reaches any size. External to the subambulacral spines, which are flattened, slightly tapering, round-tipped, and a trifle shorter and stouter than the furrow spines, are 2, 3, or even 4 longitudinal series of granules belonging to the adambulacral plates. In both specimens the mouth spines are longer than the corresponding adambulacral spines, and instead of being blunt are sharp. The granules surrounding the papular pores are only a trifle larger than the others.

Fromia monilis Perrier (1875, p. 179) has never been figured, and Doctor Koehler did not see the type when working up his Indian material (1910*a*, p. 140). No one has compared it, therefore, directly with *F. major* or *F. japonica*. It apparently has alternating large and small superomarginals and a narrow abactinal area. In fact, the description fits *japonica* fairly well up to the adambulacral plates, which have 2 furrow spines and regularly a single subambulacral, which is described as being much larger than the furrow spines, cylindrical, and terminated by an obtuse point. These spines, isolated on each plate, form the second row. On the distal half of the ray of the type of *japonica* there is only one subambulacral spine, but it is shorter and thicker than the furrow spines.

Fromia japonica differs from *F. milleporella* in having longer and slenderer rays, regularly alternating large and small superomarginal plates (at least on outer part of ray), and slightly larger granules surrounding the papular pores.

Type.—No. 743, Museum of Comparative Zoölogy.

Type-locality.—Japan.

Distribution.—Japan, Mindanao, Sulu Archipelago, Billiton, Kei Islands, to 20 fathoms. Also reported by Koehler (1910*a*, p. 140) from Indian region ("station 148, 15 to 30 fathoms," no locality).

Specimens examined.—Two:

Station 5159, off Tinakta Island, Tawi Tawi Group, Sulu Archipelago, 10 fathoms, coral sand.

Station 5251, Gulf of Davao (off Linao Point), Mindanao, 28 fathoms, coral.

FROMIA EUSTICHA Fisher.

Plate 95, fig. 2; plate 105, fig. 1; plate 106, fig. 1; plate 107, figs. 3, 5.

Fromia eusticha FISHER, 1913*c*, p. 213.

Diagnosis.—Differing from typical *F. milleporella* in having longer slenderer rays, more regularly arranged abactinal plates, only 2 adambulacral furrow spines on *distal* half of ray, and abundant actinal pedicellariae. R=41 mm., r=8.5 mm., R=4.8 r, breadth of ray at base, 9.5 mm. Rays slender, evenly tapering, abactinally plane; disk slightly convex; marginal plates very regular, mostly longer than wide, regularly decreasing in size, not alternate large and small; abactinal plates, roundish or hexagonal, sometimes with faint indication of lobing, arranged in quincunx in regular longitudinal series; actinal plates in 3 regular series at base of ray; adambulacrals with proximally 3 rather narrow furrow spines, 2 distally; 2 subambulacral spines and 1 to 3 subambulacral pedicellariae.

Description.—Abactinal plates in 5 fairly regular longitudinal series at base of ray, becoming reduced to 3 at the middle, the plates of the lateralmost series being there quite small. Three series persist to near the tip, the last 2 or 3 superomarginals being separated by only a single series. While the plates form fairly regular longitudinal series, they do not form transverse series as in *Nardoa semiregularis*, but are arranged in quincunx. Each carinal plate borders on 6 other plates—2 plates of its own series and 2 of each adradial. Sometimes there is a slight break in the regularity, and a carinal plate is surrounded by 5 or 7 abactinal plates, roundish or hexagonal. Papulae single, at the corners of the plates. The plates are nearly flat on disk and proximal half of ray, but become slightly convex on outer third. Granules of abactinal surface polygonal, close-set, fairly uniform, not larger in center of plate, about 8 or 10 in the transverse diameter of a carinal plate. Granules surrounding papular pores unequal, some of them a little larger than the granules of plates.

Superomarginal plates, 18; beyond the third, longer than high, but last 4 broader than high, the upper margin rounded and with 1 to 4 shallow notches (opposite papulae). Superomarginals encroaching conspicuously upon abactinal surface. Inferomarginals 20, the first wider than long, the second to sixteenth longer than wide, thence wider than long. Marginal plates slightly convex, the last 4 to 6 rather conspicuously so and the granules instead of being flat-topped are convex, and conspicuously larger on the middle of plate than borders. On the other marginal plates the 1 to 3 marginal series of granules are slightly smaller than the rest. Proximally a few intermarginal papulae.

Actinal intermediate plates very regular, forming transverse series as well as longitudinal. Series adjacent to adambulacrals rectangular, wider than long, and reaching to within 3 or 4 marginal plates of tip of ray. Secondaries composed of square plates about two-thirds as large as those of first series and extending three-fourths length of ray. Third series reaching one-fourth length of ray, composed of about 6 or 7 plates. Two intermediate plates correspond to 1 inferomarginal. Two series of actinal papular pores. Actinal granules increasing in size toward furrow. On proximal half of ray there are rather abundant granuliform, 2- or 3-jawed pedicellariae, from 2 to 5 times the diameter of adjacent granules, and upward of 10 to a plate (inner intermediate series). Figures will give a better idea than description of these pedicellariae.

Adambulacral plates a little wider than long. Furrow spines 3 on proximal half of ray, usually 2 on distal half, rather heavy, blunt, the median of 3 untapered, the laterals sometimes slightly tapered. Subambulacral spines 2, the aboral frequently slightly the longer, both shorter and heavier than the furrow spines. Near the tip of ray, the aboral spine only reaches any size. External to these is a series of 3 or 4 large granules, then usually an irregular series of several small granules. In the first series there are frequently 1 or 2 pedicellariae, with sometimes a third external to these. In such an event each jaw of a pedicellaria, in a way, replaces a granule.

Mouth plates with an unpaired sharp, slightly curved tooth at the inner angle (a pair on 1 plate) and 4 or 5 similar toothlike spines along the straight furrow margin. There are usually 2 similar suboral spines, all by their difference of form contrasting with the first adambulacral spine.

Madreporic body circular, situated its own diameter distant from inner border of marginal plates.

Type.—Cat. No. 32637, U.S.N.M.

Type-locality.—Station 5146, vicinity of Siasi, Tapul Group, Sulu Archipelago, 24 fathoms, coral sand, shells; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—The exact status of this form is difficult to determine, owing to there being but one specimen. It differs from *F. japonica* and *F. monilis* in having regular, uniform superomarginals, not alternately large and small ones. *F. monilis* has but 1 subambulacral spine, longer than the 2 furrow spines. *F. balansae* is a thickset form with less regular, more tumid abactinal plates, which, judging from Perrier's description (1875, p. 178) and Koehler's figures (1910*a*, pl. 18, figs. 7 and 8) does not differ very markedly from variations of *F. milleporella*. *F. eusticha* differs from *F. andamanensis* in having slenderer rays, regularly arranged abactinal plates, large marginal plates, and a different adambulacral armature.

I might add that the presence of pedicellariae forms a distinguishing characteristic if I were certain that these are constant. A specimen of *F. japonica* herewith recorded is supplied with similar pedicellariae.

FROMIA HEMIOPLA Fisher.

Plate 95, fig. 3; plate 105, fig. 2; plate 106, fig. 3; plate 107, figs. 2, 4.

Fromia hemiopla FISHER, 1913*c*, p. 214.

Diagnosis.—Differing from *F. armata* Koehler (Andaman Islands) in the absence of abactinal conical tubercles, and the slighter development of the marginal tubercles; differing from *F. milleporella* in having 1 or more tubercular granules in the center of the marginal plates of the distal three-fourths or half of ray, in having slenderer rays, and broad, but thin, spatulate furrow spines. R=36 mm., r=9 mm., R=4 r; breadth of ray at base, 10 mm.

Description.—Abactinal plates irregular as to form and arrangement, convex, the granules small, not crowded, even a trifle spaced and usually very slightly larger on middle than periphery of plate. Granules surrounding pores not larger than others.

Marginal plates convex, the granules increasing in size toward the center, where the plates of at least the distal half of ray bear 1, 2, or even more enlarged tubercular granules, there being as high as 5 to 10 on the distal marginals of the type. The first half dozen plates usually lack a tubercle, and the tubercles become a trifle more prominent as the end of the ray is approached. Superomarginals 19 or 20; inferomarginals about 23 or 24. Here and there in the superomarginal series a small plate is wedged between 2 large ones, but there is no regularity of occurrence; the small plates may be entirely absent. A series of rather prominent intermarginal pores is present.

One series of slightly tumid actinal intermediate plates extends three-fourths the length of ray; another series about half, and a third series, at the base of ray, comprises a few plates only. Proximally 2 series of pores, becoming 1, which extends as far as the inner actinal intermediate series of plates. Granules of actinal intermediate plates becoming slightly larger toward the center of plate where, distally, they are sometimes subtuberculate.

Adambulacral plates with proximally 3 or 4, or near the end of the ray 2, broad, flat, subtruncate (spatulate) furrow spines, the end of the series with a curved contour and part or all of the aboral spine usually underlying the adoral spine of the succeeding plate. Subambulacral spines 2, sometimes 3, considerably shorter, round-tipped, heavier but not broader than the furrow spines (thicker in a transverse direction), and forming a straight series. External to these are 2 or 3 granules larger than the succeeding. Part or all of a second series of smaller granules belongs to the adambulacral plates.

Mouth plates small with 4 or 5 acute marginal spines and 2 to 4 similar suboral spines. These are slightly longer than the corresponding adambulacral spines.

Madreporic body, subcircular or elliptical, slightly variable in size, situated a little less than its own diameter from inner edge of marginal plate.

Type.—Cat. No. 32638, U.S.N.M.

Type-locality.—Tonquil Island, Gumila Reef, south of Zamboanga, Mindanao.

Distribution.—Sulu Archipelago, Mindanao and eastern Palawan, reefs.

Specimens examined.—Three; besides the type 1 from each of the following localities: Tataan Pass, Simaluc Island, Tawi Tawi Group, Sulu Archipelago, coral reef.

Port Langcan, Dumaran Island, eastern Palawan, coral.

Remarks.—This form may turn out to be a variety of *F. milleporella*, although it shows decided similarities to *F. armata* Koehler, and *F. balansae* Perrier. It differs from the latter in having narrower rays, tuberculate marginals, and spatulate furrow spines. The width of the rays may be well within the possibilities of *F. milleporella* but they are longer than specimens from Samoa.

FROMIA MILLEPORELLA (Lamarck).

Asterias milleporella LAMARCK, 1816, vol. 3, p. 253, No. 35.
Fromia milleporella GRAY, 1840, p. 286.

Distribution.—Red Sea, Mauritius, Madagascar, Ceylon, to Samoa and Fiji Islands, via the Moluccas and southern Philippines; New Caledonia; also Ryukyu (Liu Kiu) Islands, Japan.

Specimen examined.—One from Babuan Island, Jolo, coral reef.

Remarks.—This specimen is small and imperfect. It does not show the characteristics of *hemiopla*.

Genus NARDOA Gray.[1]

Nardoa GRAY, 1840, p. 286. Type, *N. variolata* (Lamarck).

This old and well-known genus is greatly in need of a thorough revision. A number of species have not been figured. Koehler has rendered a great service by his descriptions and photographs of several East Indian forms (1910*a*).

During a brief visit to London in 1914 I had the opportunity of examining the specimens of *Nardoa* in the British Museum. I was able to compare several species, including the types of Perrier's *N. gomophia* and *N. obtusa*. The latter is small and, I think, immature. It seems to be scarcely comparable with large specimens of other species. Perrier compares it with *variolata*, but I could not see a close resemblance. Its relationship is with the strongly tuberculate forms, such as *frianti* and *tumulosa*. Perrier has also compared his *gomophia* with *aegyptiaca*, a comparison which threw me entirely "off the track" until I saw the type. It does not resemble *aegyptiaca* at all but closely resembles *novae-caledoniae*, judging by the specimens of the latter in the British Museum, which Perrier himself mentions (1875, p. 164) and presumably identified.

---

[1] *Melia* Gistel, Naturgeschichte des Thierreichs, 1848, p. 176. Type, *Melia variolata* (Lamarck).

Dr. H. L. Clark kindly loaned me a number of specimens which he collected at Mër (or Murray) Island, Torres Strait. These have been most valuable, and three are figured on plate 108 together with a specimen of *variolata* (No. 838, Museum of Comparative Zoölogy) from Mauritius. I am not at all certain of the identification of the specimen figured on plate 108, figure 2, which I have called *novae-caledoniae*. Without a photograph of the type, or an authentic specimen for comparison, any identification of this species must be regarded as tentative.

The few notes I was able to make in London are included in the following synopsis, which is in no sense intended as a revision of the forms studied, since much time and material will be required for that. I have suggested that *N. finschi* is synonymous with *N. pauciforis*. *N. obtusa* is not included in the key, since it is too young to be comparable with adult examples of even its nearest relatives. Only such species as I have seen are in the synopsis.

SYNOPSIS OF SOME INDO-PACIFIC SPECIES OF NARDOA.

a^1. Abactinal plates very slightly convex to markedly convex, but not high enough to be considered hemispherical or tuberculate.

- b^1. Abactinal plates forming very regular longitudinal and transverse series; furrow spines 6 or 7 ______ *semiregularis*, p. 383.
- b^2. Abactinal plates not regularly arranged in longitudinal and transverse series.
  - c^1. Abactinal plates very much larger than the papular areas, elliptical in contour and usually *with long axis of the ellipse transversely* oriented. In specimen with R 68 mm. there are 5 longitudinal series of large alternating plates between the 2 rows of superomarginals; adambulacral spinelets in 3 series, viz., 4 (or 3), 3, 3, the last granuliform. Granules surmounting the depressed convex plates nearly uniform in size, polygonal, close-set, and 2 or 3 times the size of the the granules in the depressions between the plates.[1]
    variolatus Gray (pl. 108, fig. 4).

---

[1] From Gray's specimen, Mauritius. The rays are shorter and blunter than in any other species in this section, and are not so tapered as those of species under C^2. R=68 mm., r=13 or 14 mm., R=about 5 r. The specimen figured (pl. 108, fig. 4) is from Mauritius (No. 838, Mus. Comp. Zoöl.)

c^2. Abactinal plates not ordinarily oriented transversely and in specimens with R about 70 mm. there are 7 to 10 rows of primary abactinal plates (always more than 5). The plates are smaller and roundish, but conspicuously larger than the papular areas, and those of distal third of ray are markedly small and close-set. Adambulacral armature in 3 series.

  d^1. Abactinal plates in 7 rows on basal third of ray, but fewer and irregular distally; no intermarginal or actinal papulae; abactinal papular areas with granules conspicuously larger than the rest; furrow spines about 6-------------------------*squamulosa*, p. 383.

  d^2. Abactinal plates 7 to 10, counting across ray, much larger than papular areas (whose granules are subequal to or smaller than those of plates); an intermarginal series of papulae and an incomplete series of actinal intermediate papulae; furrow spines 3 or 4.

    e^1. Rays longer, slenderer, tapering to an *attenuate*, rather sharp, extremity; R=about 6 to 7 r; abactinal plates nearly plane, or only faintly convex, their contour excavated by the papular areas, forming short irregular lobes (which can be seen only when the plates are denuded)------------------------*lemonnieri*, p. 382.

    e^2. Rays shorter and thicker, not especially attenuate at the tip; R. variable, but about 5 r; abactinal plates markedly convex, the primary plates without lobes or with only very faint lobing.

      f^1. Abactinal plates a little larger and more convex, especially on disk; granules relatively larger on the convex part of the abactinal plates, and abruptly larger, by 4 or 5 times, than granules of interstices between plates; adambulacral armature, 3, 3, 3, or 4, 3, 3; contour of plates of type, unknown (see footnote)----------------- ------------------"*gamophia*" Perrier.[1]

      f^2. Abactinal plates by direct comparison a little smaller and a little less convex; rays slightly longer and a little more attenuate distally; granules of the convexity of plates smaller and grading more gradually into the smaller granules of margins of plates and papular areas------------------*novae-caledoniae* Perrier.[2]

---

[1] The differences between *gomophia* and *novae-caledoniae* are rather difficult to express in a key, being somewhat subtle. I have, of course, relied upon the correctness of the label which designates Perrier's type in the British Museum—or, rather, upon the authenticity of the specimen. Perrier compares his specimen to *Nardoa aegyptiaca* in the following manner (1875, p. 167):

"Il existe dans la collection du British Muséum un bel échantillon d'une espèce de *Scytaster* très voisine par sa forme et son aspect général des individus de grande taille de l'espèce précédente [*aegyptiaca*]; nous proposons de lui donner le nom de *Scytaster gomophia* en souvenir du nom de genre créé par Gray pour celle-ci."

But the type does not particularly resemble *N. aegyptiaca*. It is, on the contrary, very close to the specimens of *N. novae-caledoniae* mentioned by Perrier (1875, p. 164) as being in the British Museum. I think the names refer to a single species.

The type of *gomophia* measures: R=71 mm., r=13 mm., breadth of ray at base, 16 or 17 mm. The Mër Island specimen measures: R=79 mm., r=13 mm., breadth of ray at base, 14 or 15 mm.

The type-locality of both species is New Caledonia.

I have figured (pl. 108, fig. 2) a specimen taken by Dr. H. L. Clark at Mër (Murray) Island, Torres Strait. I do not feel at all sure that this is really *N. novae-caledoniae*, but it seems at least pretty close to that species. As will be seen from the figure, it resembles *variolata*, but the abactinal plates are round instead of elliptical, and those of the distal half of the ray are much smaller and close-set. The primary abactinal plates show a very faint lobing, although a few plates are nearly entire. The adambulacral armature is 3, 3, 3, or 4, 3, 3, and a series of actinal intermediate papulae extends a little over half the length of the ray.

[2] The chief differences between the type of "*N. gomophia*" and the British Museum specimens of *novae-caledoniae* are mentioned in the key. In *gomophia* the rays are a little

c^3. Abactinal plates small, numerous, irregular, scarcely at all convex, subequal to or slightly larger than the papular areas and 10 to 13 or even more between the superomarginals, counting across ray at base; abactinal granules increasing slightly in size toward center of plates, where they are about twice as broad as in the intervals between.

d^1. Abactinal plates larger, 9 to 11 across ray at base, those of the distal third smaller and more crowded than over rest of ray, forming thus a rather definite distal area distinguishable from the proximal two-thirds; a definite series of papular areas between the inferomarginals and the actinal intermediate plates (of which there is a single series extending to end of ray). *mollis*[1] de Loriol (pl. 108, fig. 1).

d^2. Abactinal plates smaller, the smallest of any known species, at least 12 or 13 across ray at the base, those of distal third or fourth small and crowded, but the area not differentiated at all conspicuously from the rest of the abactinal surface; lateral abactinal plates abruptly much smaller than the regular superomarginals which are thus very conspicuous, a series of fairly large intermarginal papular areas but no series of actinal intermediate papulae, although 1 to a very few areas sometimes occur sporadically at base of the ray; a single series of actinal intermediate plates extending to the end of the ray; adambulacral armature: 3 (or 4), 3, 3---------------------*pauciforis*[2] (von Martens), pl. 108, fig. 3.

---

shorter and less attenuate at the extremity; the abactinal plates are slightly more convex, and the granules are abruptly larger than those of the papular areas and interspaces between the plates—about 4 or 5 times greater. In *novae-caledoniae* the granules of the convexity of the plates are actually smaller by direct comparison (about one-half to two-thirds as broad) and they grade more gradually into the small granules. In *novae-caledoniae* the length of the ray is variable, among the British Museum specimens at least.

[1] See de Loriol, 1891, p. 26, pl. 3, fig. 4; New Britain. The specimen figured (pl. 108, fig. 1) was collected by Dr. H. L. Clark on Mër (Murray) Island, Torres Strait.

[2] Probably identical with *pauciforis* is *Nardoa finschi* de Loriol, 1891 (p. 28, pl. 2, fig. 4, 4*a–g*). De Loriol compares his new species with *N. mollis* and *N. novae-caledoniae.* He says: "Dans le *Nardoa Novae Caledoniae* Perrier, les ossicules sont plus saillants, plus développés, plus serrés, les deux séries de chaque côté de la face ventrale sont moins différentes de taille, les aires porifères sont bien plus petites relativement aux ossicles, le disque est plus grand avec un plus grand nombre de plaques intercalées dans les espaces interbrachiaux de la face ventrale, les piquants ambulacraires sont differents."

Judging by de Loriol's figure of *finschi,* the abactinal plates are considerably smaller than those of *novae-caledoniae,* and the whole animal resembles more nearly the British Museum specimens of *pauciforis.* In an example of *pauciforis* (pl. 108, fig. 3), or what I believe to be this species, from Mër (Murray) Island, Torres Strait, kindly loaned by Dr. H. L. Clark, the adambulacral armature closely resembles that figured by de Loriol. The furrow spines are proximally 4, then 3, with 2 or 3 heavier spines in the first subambulacral series, and 3 or 4 granules, abruptly larger than the actinal granulation, in the third series.

Linckia pauciforis von Martens, 1866, p. 69. "Fünf platte Arme, Scheibenradius zum Armradius wie 1 : 5½. Breite der Arme an ihrer Basis zu ihrem Radius = 1 : 4–5. Höhe (an getrockneten) nur die Hälfte der Breite. Furchen papillen der inneren Reihe 3, zuweilen 4 auf jeder Platte, flach, gleich gross, nach aussen davon gleich lange dickere, im Durchschnitt drei-vieleckig, in zwei verworrene Reihen gestellt, allmählich in die Granulation der Bauchseite übergehend. Eine Reihe kleinerer Plättchen an der Bauchseite nach aussen von diesen Furchenpapillen, dann zwei Reihen doppelt so grosser Platten. Platten der Rückenseite wieder nur halb so gross, rundlich, nicht in Reihen gestellt; Granulation auf Rücken- und Bauchseite gleichmassig. Porenfelder auf der Rückenseite zahlreich zwischen den Platten vertheilt, jedes nur 4–6 Poren enthaltend; Madreporenplatte einfach.

Farbe (der trockenen Exemplare) hell gelbbraun. Armradius bis 100 Mill.

Insel Adenare bei Flores.

a^2. Some of the abactinal plates nearly or quite hemispherical, while others are less markedly convex; or else plates variably convex and some others here and there in the form of hemispherical, subcylindrical, or subconical tubercles, as high as their breadth at base.

b^1. Abactinal tubercles very prominent, acorn-shaped, or conical with the tip bare (rarely completely granular). Only 1 row of subambulacral spines, the granules on outer part of adambulacral plates being equal to those of the actinal surface---------------------- ---------*aegyptiaca* Gray.

b^2. Abactinal tubercles entirely granular; outer granules of adambulacral plates larger than *adjacent* actinal intermediate granules, so that in a measure the adambulacral armature grades into that of the actinal surface.

c^1. Abactinal plates very numerous, more nearly equal, some more conspicuously convex than others, the most prominent, hemispherical, but not so high as wide----------------------------------*tuberculata*, p. 384.

c^2. Abactinal plates very unequal in size, larger ones forming thick subconical or dome-shaped tubercles covered with granules.

d^1. Abactinal tubercles numerous, 30 or 40, more cylindrical in form. *frianti*, p. 385.

d^2. Tubercles fewer, usually about 10 to 15, some of the larger subelliptical and oriented transversely, relatively larger than in *frianti*, lower in proportion to width, and evenly rounded or dome-shaped. *tumulosa*, p. 386.

NARDOA LEMONNIERI Koehler.

Nardoa Le Monnieri Koehler, 1910*a*, p. 161, pl. 18, figs. 1 and 2.

Koehler[1] has given figures and a detailed description. In the Philippine specimen, R=110 mm., r=15 mm., R=7 r; breadth of ray at base, 16 mm. to 20 mm. If the dorsal plates are denuded, their contour is irregularly scalloped and short-lobed, the arcuate indentations being on the margin bordering papular areas. According to Viguier's figure of *N. novae-caledoniae* (1879, pl. 9, fig. 8) the dorsal plates are entire. The actinal series of papular areas, between the inferomarginals and actinal intermediate plates comprises only 6 to 9 areas, and is therefore shorter than in the type. There are usually 9 marginal mouth spines, and 6 in the parallel suboral series.

Type-locality.—Andaman Islands.

Distribution.—Known only from Andaman Islands and Sulu Archipelago.

Specimen examined.—Station 5159, Tawi Tawi Group, Sulu Archipelago (off Tinakta Island), 10 fathoms, coral sand; 1 specimen.

Remarks.—The nearest relatives of this species are *N. mollis* de Loriol (New Britain), *N. novae-caledoniae* Perrier (New Caledonia), and *N. galatheae* Lütken (Nicobar Islands and Togean Islands, Celebes). *N. galatheae* is not well understood. It is near *N. mollis* according to de Loriol, who mentions as the only differences that *gala-*

---

[1] 1910*a*, p. 161, pl. 18, figs. 1 and 2.

theae has 4 adambulacral spines in each of the 2 series, while in *mollis* there are rarely 4 in the furrow series, and 3 or 2 in the second series; and the rather negative character that Lütken does not describe the peculiar condition of the distal abactinal plates of *mollis*.

Koehler has pointed out the differences separating *N. lemonnieri* from *N. novae-caledoniae* and *N. mollis*. The scalloped abactinal plates of the *Albatross* specimen will furnish a further distinguishing feature.

NARDOA SQUAMULOSA Koehler.

Plate 105, fig. 5; plate 111, fig. 1.

Nardoa squamulosa KOEHLER, 1910*a*, p. 168, pl. 1, fig. 8; pl. 15, fig. 7 and 8.

The larger of the 2 specimens has R=41 mm., r=7 mm., and despite slight differences I think both are referable to Koehler's species. The enlarged adambulacral granules are a trifle less conspicuous than in the type. The distal marginal plates have a distinct central tubercle surrounded by granules, and the central granules of the distal abactinal plates are enlarged. The characteristic enlarged granules of the papular areas number usually 4 to 8, although distally they may be fewer. The abactinal plates have 5 or 6 short, usually overlapping, lobes.

Type-locality.—Off Cape Negrais, Burma, 40 fathoms.

Distribution.—Burma; Philippine Islands, 28 to 67 fathoms.

Specimens examined.—Two:

Station 5253, Gulf of Davao, Mindanao, 28 fathoms, coral.

Station 5482, Surigao Strait, east of Leyte, 67 fathoms, broken shells, sand, green mud.

NARDOA SEMIREGULARIS (Müller and Troschel).

Plate 105, fig. 3.

Scytaster semiregularis MÜLLER and TROSCHEL, 1842, p. 36.
Nardoa semiregularis SLADEN, 1889, p. 412.

The specimen is small and is characterized by the great regularity of the abactinal plates which are arranged in transverse and longitudinal series. R=29 mm., r=5 mm., R=6 r; breadth of ray at base, 5 to 6 mm. There are 6 or 7 spinelets in the furrow series, and usually 5 in the second series, while the original description calls for but 4 furrow spines. In the Japanese form (Misaki) there are frequently 5, and sometimes 6 furrow spines. The distal abactinal plates are very regular, not irregular, but as only the carinal series occupies the outer third of ray, separating the superomarginal plates, it is likely that the regularity may be explained by the immaturity of the specimen. This would also account for the presence of but 1 to 3 pores to each papular area. Near the end of the ray 1 to 2 subambulacral granules to each plate are enlarged, as in *N. squamu-*

losa. I find this true also of the Japanese form, as well as of *N. tuberculata*, *N. aegyptiaca*, *N. gomophia*, *N. frianti*, and *N. lemonnieri* (to a slight extent). The character is not confined therefore to *N. squamulosa*, nor to a few species only.

This species is readily distinguished from *N. squamulosa* by the greater regularity of the abactinal plates, and by the absence of the enlarged granules on the papular areas. It may be distinguished from *N. semiseriata* (von Martems) by the abactinal plates forming regular transverse and longitudinal series. In *N. semiseriata* the abactinal plates are described as being arranged in *quincunx*, with a single papular pore at the corners of the plates. This strongly suggests the genus *Narcissia*, in which *semiseriata* would seem to belong.

Type-locality.—Java.

Distribution.—Java, Palawan, and (including the form *japonica*) Japan. Sluiter[1] (1895, p. 61) records the species from the Moluccas.

Specimens examined.—Station 5357, North Balabac Strait (south end of Palawan), 68 fathoms, coral, sand.

NARDOA TUBERCULATA Gray.

Plate 110, fig. 1.

Nardoa tuberculata GRAY, 1840, p. 287; 1866, p. 15.—SLADEN, 1889, p. 413.—KOEHLER, 1910*a*, p. 157, pl. 17, figs. 1 and 2.
Ophidiaster tuberculatus MÜLLER and TROSCHEL, 1842, p. 32.
Scytaster tuberculatus PERRIER, 1875, p. 157.

Notes on Philippine specimens.—Perrier[2] has described this species and Koehler (1910*a*, pl. 17, figs. 1 and 2) has already figured it. The only important variation in the *Albatross* specimens is the presence in 3 examples (starred in the list of specimens) of numerous actinal and abactinal pedicellariae. These resemble large split granules. The abactinal pedicellariae are found on the papular areas and are several times larger than the small granules of the papular areas, and conspicuously larger than the granules on the convexity of the plates (which exceed in size those of the sunken papular areas). The actinal pedicellariae are also larger than the granules, and are found on the intermarginal papular areas, between the inferomarginal and actinal intermediate plates, and on the single series of actinal intermediate plates of the ray. Two small chevrons of actinal intermediate plates in addition to the complete series are present on the disk. Some of the actinal pedicellariae have 3 jaws

In the Buton Strait specimen the abactinal plates are considerably less convex than in the Philippine examples and if it is really *tuberculata* it is a variety intermediate between sections a^1 and a^2 of my foregoing synopsis. Without an abundance of material it is practically impossible to handle this genus with any degree of precision. In the specimen in question none of the plates is really tuberculate.

---

[1] Bijd. tot de Dierk. Konink. Zool. Genoot., Afl. 17.
[2] 1875, p. 157.

In the Celebes specimen R=106 mm., r=about 18 mm., R=about 6 r; breadth of ray at base, 20 mm. The largest Philippine example (Port Binauga, Subig Bay) has the following measurements: R=91 mm., r=15 mm., R=6 r; breadth of ray at base, 18 mm.

In the United States National Museum collection there is a small specimen bearing the number 3293 (and another number, 2100). There is no locality. This specimen has R, 48 mm. and on the abactinal surface are 25 to 27 prominent low-conical plates forming tubercular eminences among the others. Although larger than Perrier's type of *N. obtusa* this example resembles it and suggests the possibility that *obtusa* is a young *tuberculata* with the tubercules a little more prominent than usual.

Type-locality.—Luzon.

Distribution.—Philippine Islands (Luzon, Cebu, Surigao Sea, Masbate, Sulu Archipelago) to Buton Strait, Celebes; Batjan[1], Flores,[1] Batavia,[1] Amboina, New Guinea.[2]

Specimens examined.—Ten, from the following localities:

Mariveles, Luzon, 2 specimens.

Port Buanga, Subig Bay, Luzon, 1 specimen.

* Tilig, Lubang Island, off Luzon, 1 specimen.

* Port San Miguel, Ticao Island (off southern Luzon), shore; 1 specimen.

Camiguin Island, Surigao Sea, sand and coral; 1 specimen.

* Catanigan Bay, Masbate, 1 specimen.

Tataan Pass, Simulac Island, Tawi Tawi Group, Sulu Archipelago, shore; 2 specimens.

Great Tobea Island, Buton Strait (Cebeles), tide pools on coral; 1 specimen.

NARDOA FRIANTI Koehler.

Plate 109, fig. 1; plate 111, fig. 3.

Nardoa frianti KOEHLER, 1910*a*, p. 158, pl. 17, figs. 3 and 4.

Koehler has given a full description with figures. The *Albatross* specimens are nearly typical. It is to be noted here that the example from station 5190 has the granules, especially on the tuberosities, acorn-shaped and very slightly spaced, while on the other specimen the granules are flattish and closely crowded. The latter specimen has R=126 mm. and on the proximal third of the ray a series of papular areas have appeared between the inferomarginal and actinal intermediate plates, with 2 or 3 pores to each area. The smaller example with R=72 mm. has a few of these small areas at the base of the ray.

---

[1] Döderlein, 1896, p. 319.

[2] H. L. Clark, Bull. Mus. Comp. Zoöl., vol. 51, 1908, p. 283 (Sorong, New Guinea, Thomas Barbour).

Type-locality.—Andaman Islands.

Distribution.—Andaman Islands; Sulu Archipelago.

Specimens examined.—Two:

Station 5159, Tawi Tawi Group, Sulu Archipelago (off Tinakta Island), 10 fathoms, coral sand; 1 specimen.

Station 5163, Tawi Tawi Group (off Observation Island), 28 fathoms, coral sand; 1 specimen.

NARDOA TUMULOSA Fisher.

Plate 95, fig. 9; plate 109, fig. 2; plate 111, fig. 2.

Nardoa tumulosa FISHER, 1917*b*, p. 90.

Diagnosis.—In a general way resembling *N. frianti* Koehler in having prominent, large, hemispherical, abactinal plates, but these much fewer and relatively slightly larger than in *frianti*, lower in proportion to width and evenly rounded or dome-shaped. They are confined to the abactinal surface and the proximal two-thirds of ray; plates of distal third of ray small, crowded, convex; disk high. R=about 90 mm., r=about 14 mm. R=6.4 r; breadth of ray at base, 17 mm.; height of disk, 21 mm.

Description.—The general form of this species, as well as the principal differences between it and *N. frianti* are shown fairly well by the figure. The prominent tubercles number about 10 to 15 on each ray and are confined to the proximal two-thirds of the ray. Each of these prominent plates is subcircular or elliptical (in which case the long axis is transverse) and the edge of the plate is very slightly and irregularly lobed, each lobe articulating with one of the irregular smaller and lower intermediate or secondary plates. The prominent plates are dome-shaped and lower in proportion to the width than are those of *frianti*. On the outer third of the ray the plates are all small, rather strongly convex, and oriented longitudinally (at least the more prominent ones, which are irregularly elliptical in form). The abactinal granules are largest on the tuberosities, polygonal, and close-set, gradually diminishing in size toward the papular areas, where they are about half the diameter. The lower convex plates also have the central granules enlarged. The papular areas are smaller than the plates and in the type contain 15 to 30 pores, and in the smaller specimen only 6 to 10.

The proximal marginal plates are not at all globular as are some of the superomarginals in *frianti*, but are slightly convex, and the central granules are enlarged as in the case of the abactinal plates. The last 10 or 12 plates of both series frequently have the central granule enlarged into a definite thimble-shaped tubercle, or there may be 2 or 3 such granules larger than the others. Some of the distal abactinal plates are so armed. A single series of small actinal intermediate plates extends about a third the length of ray; for the remainder of the ray the large inferomarginal plates are in contact with the adambulacrals. There is a series of intermarginal papular areas but no papulae between the inferomarginal plates and the furrow. In the type there is a series of a few intermarginal plates at the base of each ray.

Adambulacral armature: Three or 4 furrow spines, blunt and usually irregularly 4-sided in section; back of these is a series of about 3 slightly thicker and much shorter, usually quadrate, truncate, or round-tipped granules; then a definite series of 3 or 4 decidedly smaller granules, intermediate in size between the first series and the actinal granulation. The outer edge of plate is filled in with 1 or 2 irregular or angular series of granules identical with those of actinal intermediate and inferomarginal plates.

Madreporic body small, circular, about midway between the middle of the elevated disk and the lower edge of the superomarginal plates.

Type.—Cat. No. 37028, U.S.N.M.

Type-locality.—Station 5160, off Tinakta Island, Tawi Tawi Group, Sulu Archipelago, 12 fathoms, sand; surface temperature 82° F.; 1 specimen.

Distribution.—Known only from Tawi Tawi and Jolo, Sulu Archipelago, 12 to 34 fathoms.

Specimens examined.—Two, the type and 1 from station 5555, off Cabalian Point, Jolo Island, 34 fathoms, coarse sand.

Remarks.—There is a very slight possibility that this form may be the adult of *Nardoa obtusa* Perrier (1875, p. 169). I examined Perrier's type, in the British Museum. Perrier does not give measurements nor does he indicate that the specimen is small. The measurements are: R=35 mm., r=8 mm. The abactinal plates are nearly hemispherical and more prominent toward the end of ray than at the base. The adambulacral armature is: Furrow spinelets 4, then 2 series of 3 granules each. I was able to compare this specimen with young *variolata*, from which it differs in having 7 plates across the base of ray (5 in *variolata*), the plates circular in form, and the secondaries larger than in *variolata*. The type of *obtusa* is from Siquijor, Philippines.

The type of *obtusa* has relatively blunter rays than the smaller specimen of *tumulosa* (R=63 mm.), and the tubercles are less prominent on the disk and the base of the rays. Just what *obtusa* would look like, if adult, is rather difficult to conjecture. A detailed comparison of the type with that of *tumulosa* is therefore omitted, because the specimens are not really comparable.

Genus OPHIDIASTER Agassiz.[1]

Ophidiaster Agassiz, Mém. soc. sci. nat. Neuchatel, vol. 1, 1835, p. 191. Type, *O. ophidianus* (Lamarck).

KEY TO SPECIES OF OPHIDIASTER HEREIN DESCRIBED.

- a^1. Center of some of the abactinal and marginal plates with 1 or more enlarged, tuberculate granules, or with single tubercles, or spines.
  - b^1. Adambulacral armature in 2 series, the subambulacral spine of irregular occurrence; marginal and abactinal plates with conspicuous central spine, or serial tubercles ________ *fuscus*, p. 388.
  - b^2. Adambulacral armature in 3 series.
    - c^1. Papulae normally in 6 longitudinal series; plates with single central tubercle; sheath of pedicellariae with margin of depression entire, not toothed or crenulate; papular areas large (except in young specimens) with 10–12 pores ________ *tuberifer*, p. 393.
    - c^2. Papulae in 8 longitudinal series; plates with several enlarged tuberculate granules; sheath of pedicellariae with crenulate or toothed margin; papular areas small, with 3 or 4 pores ______ *trychnus*, p. 390.
- a^2. Abactinal and marginal plates covered with a fine granulation without a sign of central tubercles or spines; adambulacral armature in a double series on furrow, but the regular subambulacral spine lacking except in a rudimentary condition at end of ray ________ *dubiosus*, p. 394.

OPHIDIASTER FUSCUS (Gray).

Plate 95, figs. 5, 5*a–c*; plate 103, fig. 4; plate 104, fig. 1; plate 111, figs. 5, 6.

Tamaria fusca Gray, 1840, p. 283; 1866, p. 13.
Ophidiaster fuscus Perrier, 1875, p. 132.
Linckia megaloplax Bell, 1884*b*, p. 126.

I made some notes and sketches of Gray's type and the specimens listed below appear to be fairly typical examples. The species is somewhat variable. In most cases the color is a striking combination of "Bougainvillea" purple and brown. The accompanying description and figures will probably be useful for a comparison with nearly related forms, *O. hirsutus* Koehler, for example.

Description.—General appearance very similar to that of *O. hirsutus.* The abactinal and marginal plates are strongly convex and form 7 regular series. The granules are smallest around the border of plates, increasing in size toward the center, where they are unequal, some of them being more convex than others. The granules of the papular areas are unequal in size, some being subequal to the granules of the borders of the plates, others 2 or 3 times as large. The center of the abactinal and marginal plates bears either a stout conical spine or a spine with 1 to several tubercular granules at the base, or some plates may bear 2 to 5 tubercles shorter than the spines. The largest specimen from station 5641 is remarkable for having on practically all the abactinal and on many of the superomarginal plates as well a heap of upward of 9 or 10 unequal subconical or acorn-shaped, enlarged granules instead of the spine. Most all the inferomarginal plates have the spine. Many of the abactinal and marginal plates have a large alveolar pedicellaria, sometimes 2, with a figure 8 depression into which the jaws closely fit when open. The entire apparatus is two-thirds to three-fourths the length of plate. The jaws are semicircular with 8 to 10 fine teeth and narrow abruptly into a very slender stem. The alveoles have a smooth border; rarely with 1 or 2 indentations.

---

[1] *Chione* Gistel, Naturgeschichte des Thierreichs, 1848, p. 176. Type, *Chione ophidianus* (Lamarck).

Papular areas conspicuous, in 6 longitudinal series (none actinal). Each area is smaller than the neighboring plates and contains 7 to 10 pores scattered among granules of diverse sizes.

Adambulacral armature variable so far as the actinal spine is concerned. Each plate has 2 furrow spines, or in some cases 3 at the base of ray. These are flattened, truncate, and slightly hollowed or faintly grooved on the furrow face. The adoral spine is commonly broader at tip and the aboral narrower at tip than at base; the latter appears to be slightly smaller. The subambulacral spine is thick, broadly lanceolate to subconical, blunt, and separated from the furrow spines by 1 or 2 rows of granules. It is very irregular in occurrence. At the base of the ray there is likely to be 1 to a plate (1 to every 2 furrow spines), but farther along ray any number of plates may be skipped, so that sometimes only a very few are present throughout the whole length of the furrow. Its place is usually taken by a granule slightly larger than the rest.

One series of actinal intermediate plates extends nearly to end of ray while a second series sometimes nearly reaches the middle. They are very slightly convex with slightly larger granules near the middle than on the edge. A few pedicellariae may be scattered over the actinal surface or they may be entirely absent.

Madreporic body large, but variable, subcircular with fine radiating branching striae.

Color in alcohol, light brown marked on the disk, base of rays, and by 2 cross bars on the rays, with a brilliant light pinkish purple. The specimen from station 5641 lacks purple and is mottled with darker brown.

Type.—British Museum.

Type-locality.—Migupou (probably a Philippine locality).

Distribution.—Philippine Islands (Gulf of Davao, Mindanao), Celebes, and northwestern Australia, to 39 fathoms.

Specimens examined.—Six:

Station 5248, off Lanang Point, Gulf of Davao, Mindanao, 18 fathoms, coral; 1 specimen.

Station 5251, off Linao Point, Gulf of Davao, Mindanao, 20 fathoms, coral; 1 specimen.

Station 5252, same locality, 28 fathoms, coral; 1 specimen.

Station 5253, same locality, depth and bottom; 2 specimens.

Station 5641, off Kalmo Point, Buton Strait, Celebes, 39 fathoms, sand, shells; 1 specimen.

Remarks.—Koehler (1910*a*, p. 149, pl. 18, figs. 5 and 6) has described a very closely related form, *O. hirsutus* from the Andaman Islands, 11 to 25 fathoms, which may prove to be but a race of *fuscus*. It lacks pedicellariae and has an inconspicuous actinal intermediate series of papulae at base of ray, as well as a few other minor differences, including color.

I have examined a specimen of *Linckia megaloplax* from the *Alert* collection (Museum of Comparative Zoölogy) and I think it is very probably the same as *Ophidiaster fuscus*.

OPHIDIASTER TRYCHNUS Fisher.

Plate 84, fig. 5; plate 95, figs. 6, 6*a*–*d*; plate 103, figs. 2, 3; plate 107, fig. 6.

Ophidiaster trychnus Fisher, 1913*c*, p. 215.

Diagnosis.—Differing from *O. pusillus* Müller and Troschel in having the papulae in 8 longitudinal series, and the central granules of the abactinal, marginal, and actinal plates enlarged, and subtuberculate on outer part of ray, and in having the pedicellaria sheaths toothed, not entire; differing from *O. tuberifer* in having 8 longitudinal series of papular pores, much larger and broader pedicellariae, with the sheaths toothed, not entire, and in having a number of enlarged granules on the plates, not a single conical tubercle of predominant size. R=19 mm., r=4 mm., R=about 5 r.; breadth of ray at base, 5 mm. Rays cylindrical, only very slightly tapering, with a blunt extremity capped by a dorsal, convex, roundish terminal plate.

Description.—Seven series of abactinal and marginal subcordate plates, the adoral narrower end overlying the broader aboral end; 2 series, on either side, of smaller actinal intermediate plates, the inner extending to within 4 inferomarginal plates of end of ray, the second extending nearly half the length of ray. Abactinal and marginal plates slightly tumid, each longitudinal series forming a low convex ridge, separated by relatively shallow, but very evident, furrows, containing the series of papular areas (8 in all). Granules slightly spaced to contiguous, but not crowded; very unequal as to size and form. Those covering papular areas are small and unequal, but usually a little smaller than the pores themselves; next larger are the granules between consecutive pore areas and along the transverse margins of the plate, whence they increase very rapidly in size toward the center of plate, the greater part of whose area is occupied by blunt, broadly subconical, unequal, sometimes tuberculate granules, of which 3 to 10 are of preeminent size, and either touch or are very slightly spaced, the groups being usually wider than long—that is, transversely oriented. These granules increase slightly in length on the outer part of the ray, especially on the marginal plates, 1 to 4 having the form of blunt conical tubercles. On the actinal intermediate plates the granules are also unequal, several in the middle of plate being subtuberculate and only a little smaller than the adjacent outer series of adambulacral tubercles. At the base of the ray 8 or 9 granules can be counted across the widest part of the plate. Terminal plate dorsal in position, subcircular, or a little wider than long, convex, with 2 or 3 tubercular prominences in a transverse series.

Relatively large 2-jawed excavate pedicellariae occur in very variable numbers on the abactinal, marginal, and actinal intermediate plates. They are more numerous in the cotype than in the type, there being 1 or sometimes 2 on a majority of the plates. The form into which the jaws fit when open is of the usual figure-8 shape, obliquely and longitudinally oriented, and is nearly as long as the plate. Each jaw is broadly spatulate, semicicular distally, broader than in *O. germani*, and has 4 or 5 relatively large teeth with corresponding indentations on the edge of the form. In well-formed pedicellariae the diameter of distal expanded part of the jaw is about that of the large granules. The alveolar "form" is excavated from the plate itself and has a conspicuously elevated rim. The exact form is best seen from the figure (pl. 95, fig. 6*a–b*).

Abactinal papulae do not reach the end of ray, but the intermarginal series comes within about 3 superomarginal plates of the tip. Actinal intermediate series extends about half the length of ray. Abactinal and intermarginal papulae, usually 3 to an area; actinal intermediate papulae, 3, 2, and 1.

Adambulacral plates wider than long, obliquely oriented; furrow spines 2 flattened, the adoral broadly spatulate, roundly truncate, about twice as long as breadth at tip, the aboral slightly shorter, much narrower, slightly tapering, and blunt. Forming a transverse oblique, adorally trending series with the larger furrow spine, and without intervening granules, is first a shorter compressed, broad, round-tipped granule, then a longer, much thicker ovoid or acorn-shaped slightly flattened tubercle, about as long as the larger furrow spine, but much more conspicuous. Between these consecutive transverse series is a transverse series (occasionally 2) of elongate, bluntly pointed granules; and external to the series of tubercles is a less regular series of shorter actinal intermediate tubercles, interspersed with a few longitudinally oriented pedicellariae. The outer adambulacral tubercle is directly behind the median, and that is nearly opposite the interval between the adoral larger spine of one plate and the aboral spine of the adjacent (adoral) plate. This is due to the oblique orientation of the plates.

Madreporic body large, with irregular, branched, centrifugal striae. It is situated on the adradial series of plates, nearer to margin than to center of disk.

Anal aperture surrounded by about 6 subtriangular granules, larger than the other granules.

Type.—Cat. No. 32639, U.S.N.M.

Type-locality.—Port Palapag, north coast of Samar; no record of depth or bottom, but probably collected on reef; 2 specimens.

Distribution.—Samar and vicinity, to 67 fathoms.

Specimens examined.—The types and a very small specimen, probably belonging to this species from station 5482, Surigao Strait, east of Leyte, 67 fathoms, broken shells, sand, green mud.

Remarks.—This species is distinguished from the great majority of Ophidiasters by having the adambulacral armature in 3 series. It seems to require comparison chiefly with *O. pusillus* Müller and Troschel, from which it differs in having the papular areas in 8, not 6, longitudinal series, in having the sheaths of the pedicellariae toothed to correspond with the serrate blades, not entire as described by Perrier (1875, p. 131). The granules are more tuberculate on the center of the plates, especially the marginals, and the inner subambulacral spine is opposite an interval between 2 furrow spines, whereas in *pusillus* Perrier states that this spine is opposite the smaller of the furrow spines. *O. pustulatus* von Martens is described as having the furrow spines in 3 series, which would seem to ally it with the present form, but Döderlein (1896, p. 317) believes that this species is identical with *O. purpureus* Perrier, which is figured by de Loriol (1885, p. 14, figs. 3–3*h*). *O. purpureus* has the adambulacral armature in 2 series, and furthermore is characterized by having a granule between the furrow spines (and facing the furrow), a feature which it shares with *O. cylindricus* Müller and Troschel and *O. squameus* Fisher. If Döderlein is correct, *O. pustulatus* is not closely related to *O. trychnus*. But aside from this, *O. pustulatus* has longer rays (R=9 r) a more uniform granulation (not at all tuberculate), and less numerous subambulacral spines.

The few Indo-Pacific species of *Ophidiaster* having the adambulacral armature in 3 longitudinal series along the ray may be briefly contrasted as follows:

*a*¹. Some of the abactinal and marginal plates with a central tubercle, or several conspicuous tuberculate granules, especially on the distal part of the ray.

*b*¹. Excavate pedicellariae present; subambulacral spines of a plate contiguous.

*c*¹. Papulae normally in 6 longitudinal series; plates with single central tubercle; sheath of pedicellariae with margin of depression entire, not toothed or crenulate; papular areas large (except in young specimens) with 10–12 pores__________________*O. tuberifer* Sladen (Andaman Islands, Sulu Archipelago, Torres Straits).

c^2. Papulae in 8 longitudinal series; plates with several enlarged tuberculate granules; sheath of pedicellariae with crenulate or toothed margin; papular areas small with three or four pores.
O. trychnus Fisher (Samar).

b^2. No pedicellariae; subambulacral spines of a plate separated by granules.
O. ornatus Koehler (Ceylon).

a^2. Abactinal and marginal plates without tubercles or tuberculate granules.

b^1. Excavate pedicellariae, with entire, not crenulate, sheaths; abactinal and marginal plates not strongly convex and naked centrally.
O. pusillus Müller and Troschel (New Caledonia, Philippine Islands).

b^2. No pedicellariae; abactinal and marginal plates tumid or nodose, with naked central area__________*O. triseriatus* Fisher (Hawaiian Islands).

OPHIDIASTER TUBERIFER Sladen.

Ophidiaster tuberifer SLADEN, 1889, p. 404, plate 65, figs. 1 to 4.

Notes on Philippine specimens.—There are two specimens, one quite small and the other unusually large. Both differ from typical *O. tuberifer*, but nevertheless seem referable to this species. The smaller example, with R equaling 20 mm., differs in one important respect from the type. In Sladen's specimens the papular areas are large, with 10 to 12 or sometimes more, papulae, but in the Philippine example there are only about three papulae to each area. The pedicellariae are a little larger than in Sladen's figure, and many of the adradial plates are provided with a central tubercle. The granules are also somewhat coarser. Whether these differences are racial or fall within the normal age or individual variation of *O. tuberifer* can not be determined. The presence of six series of papular areas, and numerous pedicellariae with smooth bordered sheaths, together with a triseriate adambulacral armature would suggest *O. pusillus* Müller and Troschel, but so far as known that form does not have central tubercles on any of the abactinal or marginal plates. In the specimen under consideration most of the marginal, carinal, and many of the distal adradial plates (as well as a few of the proximal) have a central tubercle, sometimes two.

The measurements of the larger specimen (station 5147) are as follows: R=67 mm., r=9 mm., R = 7.4 r; breadth of ray at base, 10 mm. The most important difference presented by this specimen is the irregularity of the adambulacral armature which is biseriate except for a short distance at the base of ray. The armature appears to be demoralized, as there is no regularity. Many plates lack subambulacral spines altogether. When one is present it is usually separated from the furrow spines by 2 rows of granules; when 2 are present, which is relatively seldom, a series of granules separates them, and also the inner from the furrow spines. The outer spine is also smaller than in Sladen's figures. There are usually 2 but sometimes 3 furrow spines, the adoral the largest. The carinal series lacks tubercles, as did Koehler's Andaman specimen. The granules, pedicellariae, papulae, and general appearance indicate that this specimen is *O. tuberifer* or at most a variety. The papular areas are large and in 6 longitudinal series with upward of 18 pores to an area on the disk, and 15 on the ray, the number decreasing toward the end of ray.

The abundant pedicellariae would readily distinguish this specimen from *O. ornatus* Koehler, to which the granules between the subambulacral spines would suggest an alliance. The biseriate and generally irregular character of most of the adambulacral armature does not at all conform to the triseriate separated armature of *ornatus*. This specimen is certainly not normal.

Type.—In the British Museum.

Type-locality.—*Challenger* station 186, Torres Strait, off Cape York, 8 fathoms, coral mud.

Distribution.—Torres Strait; Andaman Islands, 53 fathoms (Koehler); Thursday Island (Döderlein); Sulu Archipelago.

Specimens examined.—Two:

Station 5153, off Tocanhi Point, Tawi Tawi Group, Sulu Archipelago, 49 fathoms, coral sand, shells.

Station 5147, 8.4 miles southwest of Sulade Island (near Jolo), Sulu Archipelago, 21 fathoms, coral sand, shells.

OPHIDIASTER DUBIOSUS (Koehler).

Plate 110, fig. 2; plate 111, fig. 4.

Linckia dubiosa KOEHLER, 1910*a*, p. 155, pl. 18, fig. 10, 11.

Notes on Philippine specimen.—In the possession of a few excavate slender pedicellariae, this specimen differs from the type. The abactinal plates are a trifle more convex, and, as noted in the description below, there is present a rudimentary subambulacral spine or granule near the tip of ray. Otherwise the specimen agrees very well with the description given by Koehler. To be sure the madreporic body is subtriangular, but that is always subject to considerable variation in this genus.

The species may be characterized as resembling *O. sclerodermus* Fisher and *O. tenellus* Fisher, but with more tumid and more regularly arranged abactinal and marginal plates, few or no pedicellariae, and no subambulacral spines, except in a rudimentary state at end of ray.

The following is a description of the specimen:

R=55 mm., r=7.5 mm., R=7.3 r; breadth of ray at base, 8 to 8.5 mm. Plates arranged in very regular longitudinal and transverse series. Abactinal and marginal plates roughly shield-shaped, nearly equal, separated by very regular series of papular areas, 6 in all. Plates evenly convex, the sulcuses separating the longitudinal rows of plates being deeper than the transverse sutures. Papular areas much smaller than the plates, containing 3 to 5 pores; no papulae on actinal surface. Plates overlaid by a close covering of nearly uniform small granules, about 20 in the diameter of a proximal carinal plate. They are very slightly smaller in the sulcuses between the plates. A very few alveolar pedicellariae with slender curved jaws are present on abactinal surface. They resemble the pedicellariae of *O. sclerodermus* (Fisher, 1906, pl. 31, fig. 2).

One series of actinal intermediate plates extends nearly to tip of ray, a second series about half length of ray, and a third series to about the fourth inferomarginal. These plates are covered with a close uniform rather fine granulation similar to that of the abactinal and marginal plates.

Adambulacral plates with an apparently double furrow series but no subambulacral spine or granule until near the tip of ray. Proximally the plates have 3 short, broad, subtruncate spinelets set slightly obliquely, so that 2 appear to be on the edge of furrow, and the third (which is the adoral) back slightly, partly behind the middle spine of its own plate and the aboral spine of the adjacent adoral plate. This spinelet is a little heavier than the other 2, which are marked by a shallow sulcus running the whole length. On the outer third of ray a fourth granule, subspherical, and similar to the adoral granule just spoken of, stands obliquely adorad of the latter and represents apparently the true suboral spine. It forms with the median and adoral furrow spine (the latter being off the furrow margin) an oblique transverse series, usually without intervening granules. Throughout most of the ray, therefore, there is only the double furrow series, the true subambulacral granule appearing in a rudimentary form at the end of ray.

Madreporic body subtriangular, slightly nearer the margin than center and marked by fine, irregular, radiating striae.

Color in alcohol, light brown mottled with darker, the sulcuses frequently marked with darker brown.

Type-locality.—Andaman Islands.

Distribution.—Andaman Islands and Surigao Strait, to 67 fathoms.

Specimen examined.—Station 5482, Surigao Strait, east of Leyte (4.5 miles southeast of Cabugan Grande Island), 67 fathoms, broken shells, sand, green mud.

Remarks.—Despite slight points of difference, such as the possession of a very few pedicellariae, I think the Philippine specimen is referable to Koehler's species, the type of which is smaller (R=28 mm.). This would partly account for the absence of pedicellariae.

I have placed the species in *Ophidiaster* because the plates are very regularly arranged in longitudinal series, a few pedicellariae are present very similar to those of *O. sclerodermus*, and lastly because near the extremity of the ray a rudimentary subambulacral spine or granule makes its appearance. I recall that the species presents several analogies to *Linckia;* it will not be surprising if the genera actually intergrade.

O. dubiosus resembles *O. rhabdotus* Fisher (Hawaiian Islands) but the latter has an actinal series of papular pores (8 series in all) and large, spatulate subambulacral spines. *O. sclerodermus* Fisher and *O. tenellus* Fisher (Hawaiian Islands) and *O. tumescens* Koehler (Aru Islands) are characterized by having no actinal papulae, but all three are provided with well developed subambulacral spines. In fact the absence of these in *O. dubiosus* separates it from all other Ophidiasters.

I have never seen *Ophidiaster pusillus* (Müller and Troschel), but judging by Perrier's observations (1875, p. 128) that species resembles a *Linckia.* Perrier states that in certain respects its adambulacral armature is intermediate between that of *Linckia* and *Ophidiaster.* The pedicellariae have a different form to those of *dubiosus*, being shorter and denticulate.

Genus LEIASTER Peters.

Leiaster Peters, Monatsber. d. k. preuss, Akad. d. Wiss. Berlin, Apr. 1852 p. 177. Type, *L. coriaceus* Peters.

LEIASTER ANALOGUS Fisher.

Plate 84, fig. 1; plate 95, fig. 7; plate 112, fig. 1.

Leiaster analogus Fisher, 1913c, p. 215.

Diagnosis.—Resembling *L. coriaceus* Peters in having grooved furrow spines, but differing in having longer, slenderer rays, numerous pedicellariae, and the abactinal papulae in very definitely circumscribed areas. Differing from other species of *Leiaster* in having channeled furrow spines. R=125 mm., r=13.5 mm., R=9 r; breadth of ray at base, 15 mm. Rays unequal, the longest 8.5-9 times as long as width of ray at base.

Description.—General form closely resembling that of *L. leachii.* Whole body overlaid by thick tough skin obscuring, unless dried, the outlines of the 4-lobed, smooth plates, which are arranged in regular longitudinal and transverse series. There are 7 longitudinal series of abactinal and marginal plates, and on either side 2 series of smaller actinal intermediate plates, 11 series in all. Pedicellariae very inconspicuous unless specimen is dry; after drying they become conspicuous. They are situated on the edge of the plates or on margin of papular areas, and each consists of 2 very slender spatulate curved jaws which fit into smooth depressions of a roughly crescent-shaped calcareous piece, embedded in the skin. One to 4 of these are present on most of the papular areas. Each apparatus is about one-fourth or one-fifth the transverse diameter of the plate in length. A few calcareous grains are scattered in the skin of the papular areas and can be seen only when specimen is dry. There are no granules whatever on surface of plates as in *L. leachii.*

Papular areas slightly sunken, in 8 regular longitudinal series, each area before drying appearing slightly larger than the adjoining plates; after drying, slightly smaller. Before drying the areas of a series appear to be nearly or quite confluent; after drying they become sunken and this appearance is lost. There are 15 to 35 pores to an area.

Adambulacral spines slender, of uniform width, truncate or round-tipped, subequal, and one-half to one-third longer than the base line of the comb. They are marked by a shallow grove from near the base to near the tip—the groove not reaching either end. This marking is best shown on the proximal half of ray, being often rather faint on the spines of the distal half. Three is the commonest number, but many plates of the type have 4. The furrow spines are united by a continuous membrane, their tips forming a scalloped edge to the furrow margin. The actinal spine is heavy, subcylindrical, and a little longer than the furrow spines, having often a slightly swollen and flattened tip. On the outer part of the ray the spine usually skips 2 plates, but at the base frequently occurs on every other plate. One specimen has 4 rays, the rest 5.

Type.—Cat. No. 32640, U.S.N.M.

Type-locality.—Station 5165, off Observation Island, Tawi Tawi Group, Sulu Archipelago, 9 fathoms, coral; 4 specimens.

Distribution.—Known only from the type-locality.

Remarks.—This form agrees with *Leiaster coriaceus* Peters in having grooved furrow spines. It differs from *coriaceus* in having abundant pedicellariae, longer, slenderer rays, less flattened dorsally, in having the abactinal papulae in perfectly circumscribed areas (not scattered indefinitely everywhere), and in having the furrow spines untapered and truncate. The skeleton appears to be more regular than in adults of *coriaceus*. *L. analogus* differs of *L. leachii* in having perfectly smooth plates, not finely granulated ones, in having more numerous and grooved adambulacral furrow spines, and in having abundant pedicellariae. *L. speciosus* is described as differing from *L. leachii* only in possessing pedicellariae. On account of the presence of pedicellariae I was at first inclined to regard *analogus* as a race of *speciosus*, but if *speciosus* is really so close to *leachii* the relationship of *analogus* can not be in that direction, for it lacks the fine granules figured and described by de Loriol as characterizing the plates of *leachii;* moreover both *leachii* and *speciosus* have only 2 ungrooved furrow spines, while *coriaceus* and *analogus* have 3 (or 4) grooved spines. Apparently, then, *analogus* bears much the same relation to *coriaceus* as *speciosus* does to *leachii*. On the other hand, in the form of the ray and the regularity of its plates, *analogus* resembles more nearly *leachii*.

L. glaber and *L. callipeplus* lack pedicellariae and have furrow spines without grooves.

Genus BUNASTER Döderlein.

Bunaster Döderlein, 1896, p. 317, pl. 22, figs. 1*a–g*. Type, *B. ritteri* Döderlein.

BUNASTER LITHODES Fisher.

Plate 95, figs. 8, 8*a–b*; plate 124; fig. 4.

Bunaster lithodes Fisher, 1917*b*, p. 91.

Diagnosis.—Very close to *B. ritteri* in general appearance, but differing in lacking the curious ball-and-socket granules of that form, and in having abundant, low, bivalved pedicellariae on the papular areas, and a few narrow spatulate tongs-shaped pedicellariae on the abactinal plates: outer actinal intermediate plates larger than the inner, and subambulacral spines slightly narrower: granules between the naked areas of plates smaller and more numerous. R = 22 mm., r = 5 mm., R = 4.4 r; breadth of ray at base, 6 mm.

Description.—In the arrangement, form, and surface of plates very similar to typical *Bunaster ritteri*, but on account of the specimen being much larger than the type of *ritteri*, the intermarginal and adradial plates extend farther along the ray, and the second, or outer, actinal intermediate series is lacking only on a trifle less than the terminal third of the ray. The number of plates in each of the marginal and in the radial series has increased. The form of the naked part of the plates is best seen in the photograph. They resemble, in miniature, irregular boulders set in coarse, pebbly mortar. The surface of the plates, like that described and figured for *ritteri*, is rough with regular microscopic bosses which, when viewed under the microscope, remind one very strongly of the compound eye of an insect. These bosses decrease in size toward the middle of the plate, and are found also on the surface of granules. The larger plates also have whitish swellings on the surface, sometimes elongate, sometimes small, roundish, and upward of 5 or 6 in number. Abactinally the plates are separated on the oblique transverse sutures by 2 or 3 series of granules, and usually by 3 to 5 along the longitudinal.

Superomarginals 17 or 18; inferomarginals the same; visible intermarginals about 13 or 14. A second row of intermarginals consisting of about 3 small plates is found in the arm-angle ventral to the main series. Both supero-and inferomarginals are oriented as in *ritteri*—obliquely with the actinal end pointing toward the mouth, and the relative size and form of the exposed surface is as in *ritteri*. The inferomarginals are nearly elliptical and narrower than the superomarginals which are oval, the broad end actinad. Terminal plate large, almost identical with that of *ritteri*.

The outer row of actinal intermediate plates has the exposed surface, which is elliptical or roundish, conspicuously larger than that of the inner row, at least for half the length of ray. The outer series extends about two-thirds the length of ray, and 2 or 3 irregular series of granules separate them from the inferomarginals, and 1 or 2 from the inner series, while transversely, the plates of each series are separated by 2 or 3 rows of granules.

Each adambulacral plate has 2 furrow spines, rounded truncate, about twice as long as broad, and the adoral a trifle narrower than the other. The subambulacral spines are narrower than figured for *ritteri*, elliptical in shape, separated from the furrow spinelets (which extend above the level of the granules for about half their length) by usually a single series of granules, and from one another by 1 or 2 series. Usually at the base of the spines in the interval between them is an enlarged granule which is most prominent on the middle third of the ray. These granules, which vary in size from 2 to 5 times the diameter of the others usually are separated from the adjacent spines by a single series of very small granules.

Papular areas in 10 longitudinal series with usually 3 papulae to an area: 4 abactinal, 2+2 intermarginal, and 1+1 actinal intermediate.

The peculiar sphaeridialike structures described as pedicellariae by Döderlein in *B. ritteri* seem to be entirely absent. But each papular area has 1 to 3 low bivalved pedicellariae, whitish in color, and each valve is about 1.5 to 2 times the size of an adjacent granule. The contour of the pedicellaria is that of a fairly broad ellipse with the ends truncated. A few of the abactinal and marginal plates have a tongs pedicellaria with two slender spatulate jaws, 1.5 to 2.5 times as long as their breadth at base, which fit into conspicuous depressions of the plate when open. (See figs. 8*a*–*b*, pl. 95.)

The madreporic body, just outside a primary basal plate has branched radiating ridges and narrow deep striae.

Color of dried specimen, burnt umber marbled on the rays with Naples yellow.

Type.—No. 2198, Museum of Comparative Zoölogy.

Type-locality.—Apo Reef, Mindoro Strait, Philippines.

Specimen examined.—The type is the only known specimen.

Remarks.—I am greatly indebted to Dr. H. L. Clark for permission to describe and figure this form, which was not taken by the *Albatross* expedition.

Bunaster ritteri is from Amboina.

Genus LINCKIA Nardo.

Lin[c]kia[1] NARDO, Oken's Isis, 1834, p. 717. Type, *L. typus* Nardo=*L. laevigata* (Linnaeus).

KEY TO THE SPECIES OF LINCKIA HEREIN LISTED.

a^1. Furrow spines separated by several granules in a perpendicular series.

b^1. In large specimens R=more than 6 r; rays 9 times as long as wide; papular areas numerous, small, about the size of the plates, 6 to 12 pores; no median radial area free from papular areas; 2 or 3 madreporic bodies ---------- *multifora*, p. 400.

b^2. R=about 6 r; rays 5 times as long as wide; papular areas superficially larger than the plates; a median radial area free from papular areas; 1 madreporic body ---------- *laevigata*, p. 400.

a^2. Furrow spines not separated by several granules in a perpendicular series. *guildingii*, p. 401.

LINCKIA LAEVIGATA (Linnaeus).

Asterias laevigata LINNAEUS, 1858, p. 662.
Linckia laevigata LÜTKEN, 1871, p. 265.

Specimens examined.—Twenty-four from the following localities:

Apra Bay, Guam, 4.

Tilig, Lubang Island, off Luzon, coral reef, 2.

Pandanon Island, between Cebu and Bohol, coral, 2.

Port Palapag, Samar, 1.

Port Langcan, Dumaran Island, eastern Palawan, coral, 1.

Machesi Island, eastern Palawan, coral, 1.

Tara Island (small island off west coast), Mindoro Strait, 2.

Tataan Pass, Simaluc Island, Tawi Tawi Group, Sulu Archipelago, shore, 6.

Station 5558, Cabalian Point, Jolo Island, 15 fathoms, coral, 1.

Balayan Bay, shore, 1.

West coast Palani Island, 2.

No locality, 1.

Distribution.—Red Sea, Mozambique, Mauritius, Zanzibar, Persian Gulf, Madras, Andaman Islands, Flores, Timor, Celebes, Batjan, Philippines, Amboina, New Guinea, New Caledonia, Guam, Caroline, Fiji, Samoan and Hawaiian Islands.

LINCKIA MULTIFORA (Lamarck).

Asterias multifora LAMARCK, 1816, p. 565.
Linckia multifora LÜTKEN, 1871, p. 267.

Specimens examined.—Three from the following localities:

Bay of Apra, Guam.

Tomahu Island, near Bouro Island, Molucca Islands, tide pools.

Papatag Island, Tawi Tawi Group, Sulu Archipelago.

---

[1] Johannes Gistel, Naturgeschichte des Thierreichs, 1848, makes a new genus *Undina* for *Linkia* Nardo. *Undina* is preoccupied in fishes. He also makes a new genus *Catantes* for "*Linckia* Agassiz." In other words, he coins two new names for the same generic group. There was no necessity for these new names.

Distribution.—Red Sea, Mozambique, Mauritius, Sulu Archipelago, Celebes, Molucca Islands, Amboina, New Caledonia, Fiji, Samoa, Guam, Hawaiian Islands.

Remarks.—The specimen from Tomahu Island is a comet form, and has only a very few granules between the furrow spines. The subambulacral series of enlarged granules is, however, separated from the furrow spines by 1 or 2 series of small granules. The example from Papatag Island is quite small (R=26 mm.) and no granules have yet appeared between the furrow spinelets. This specimen would be classified as *L. ehrenbergii* if the subambulacral enlarged granules were not well spaced from the furrow spines; in *L. ehrenbergii* they are contiguous.

These three specimens appear to be quite distinct from a young *L. laevigata* (R=25 mm.) from station 5558. The latter has a median radial area free from papulae and 1 madreporic body; the 3 specimens of *multifora* have 2 madreporic bodies, and no median radial area free from papulae.

LINCKIA GUILDINGII Gray.

Linckia guildingii Gray, 1840, p. 285 (St. Vincent).
Linckia pacifica Gray, 1840, p. 285 (Tahiti).
Linckia diplax Müller and Troschel, 1842, p. 30.

One specimen with R equaling 215 mm. from Jolo (shore).

Distribution.—West Indies, Bermuda, Vera Cruz, Bahia, Abrolhos Reefs, Cape Verde Islands, Mauritius, Madagascar, Persian Gulf, Andaman Islands, East Indies, Tahiti, New Caledonia, Fiji, Tonga, Samoan, and Hawaiian Islands.

Remarks.—*Linckia guildingii*, *L. pacifica*, and *L. diplax* have been separated on the basis of very variable characters, such as the number of madreporic bodies and length of ray. No one has been successful in pointing out any constant differences of importance between *L. guildingii* and *L. pacifica.* Much the same difficulties have been encountered in separating *diplax* and *pacifica*, while *guildingii* and *diplax* are practically identical, even to the duplication of the madreporic body.

The specimen collected by the *Albatross* is large, has one madreporic body, and would therefore be ranked with *L. pacifica* of authors.

Family GANERIIDAE Perrier.

Genus TARACHASTER Fisher.

Tarachaster Fisher, 1915*c*, p. 216. Type, *T. tenuis* Fisher.

Diagnosis.—Rays slender, disk small; dorsolateral plates 4-lobed, imbricated in regular transverse and longitudinal series; plates of median radial region mostly 3-lobed, irregularly imbricated, marginal plates actinal in position, separated from adambulacrals over most of ray by a single series of actinal intermediate plates, and on disk by small plates in transverse series; actinal interradial areas small; papulae single in the small interspaces between abactinal plates; plates convex and armed with a group of short, blunt, spinelets resembling parapaxillae or pseudopaxillae, 15 to 20 to a plate; marginal and actinal spinulation compact; adambulacral plates small with slightly curved furrow margin; spines small, crowded, grading into actinal spinulation; proximally 5 or 6, distally 3 or 4 furrow spines, with 2 to 4 crowded series each of 2 or 3 subambulacral spines. Well-developed superambulacral ossicles; ampullae double; tube feet rather small, with well-developed sucking disks.

Remarks.—It is difficult to place this genus. The presence of double ampullae, closely placed and regularly imbricated plates, and presence of superambulacral ossicles debar it from the Echinasteridae. The two other available families are the Ganeriidae and Asterinidae. While *Tarachaster* resembles *Nephanthia* superficially, on account of the radial zone of irregularly arranged plates, I think its relationships are more with the Ganeriidae. Superambulacral ossicles have not been reported in either the Ganeriidae or Asterinidae. The imbricated pseudopaxillae, with definite lobes, the definite but not particularly conspicuous marginals, the actinal intermediate plates in transverse columns, and the character of the adambulacral armature are not dissimilar to these features in the Ganeriidae. The slender rays and very reduced actinal interradial areas are new to the Ganeriidae, but in the Asterinidae a parallel case is found in *Nepanthia*, where the character varies within the genus. But *Tarachaster* does not seem to me to be closely related to any known genus of the Ganeriidae. The superambulacral plates remain something of a problem.

TARACHASTER TENUIS Fisher.

Plate 41, figs. 7, 7*a*; plate 120, fig. 4; plate 121, fig. 3; plate 126, fig. 1.

Tarachaster tenuis FISHER, 1913*c*, p. 216.

Diagnosis.—Rays 5. R=67 mm., r=12 mm., R= 5.5+r; breadth of ray at base 14 mm.; rays depressed, rather slender, long, bluntly pointed; disk small; sides of ray rounded and occupied by the abactinal plates; abactinal plates small, those on disk and along radial area of ray irregularly three-lobed, imbricating; dorsolateral, lateral, and narrow portion of ventral surface occupied by four-lobed plates in about 10 longitudinal series at base of ray, also forming transverse series; 3 series of larger plates adjacent to adambulacrals, the outer two being the marginals; plates covered by small, stout, upright, round-tipped, often clavate, close-set spinelets in groups resembling low parapaxillae, 15 to 20 to a group; single papulae between the abactinal plates; adambulacral plates small, armature dense, upright, the spinelets grading from the furrow series into those of the actinal intermediate and marginal plates; furrow spines proximally 5 or 6, distally 4 or 5, prismatic or four-sided, blunt or truncate, the proximal and distal shorter than the central 3 or 4; subambulacral spines in 2 or 3, sometimes 4, series, with 2 or 3, or proximally 4, shorter, less stout spines in each series. General appearance suggestive of a *Henricia* with closely placed plates.

Description.—The center of disk and a broad radial streak is paved with close-set, irregularly placed plates bearing a paxilliform group of 15 to 20 short, cylindrical, untapered, round-tipped spinelets either standing erect or diverging. On either side and occupying the dorsolateral, lateral, and part of actinal surface are 10 longitudinal series of close-set plates which also form regular transverse series, and each bears a roundish, flat-topped, paxilliform. group of 15 to 20 short, equal, blunt spinelets, in every way similar to those of the radial areas. As noted above the plates are not arranged in quincunx, but in fours, four of them forming a nearly perfect square. At the corners of the regularly arranged plates as well as on the radial areas and disk are single papulae. Adjacent to the adambulacral plates, and actinal in position are 3 series of close-set, rather irregularly elliptical plates, abruptly larger than the dorsolaterals and without papulae between them. The outer 2 are the marginals and the inner series is actinal intermediate. The superomarginals are slightly the largest.

The marginal and the actinal intermediate plates on the ray, usually, also form pretty definite transverse series and all are covered closely with short, relatively thick, round-tipped spinelets a trifle larger than the dorsolateral spinelets. The spinelets form not very regular 4-sided groups—about 20 to a plate. On the disk several additional series of small actinal intermediate plates are interpolated so that the marginals withdraw to about the middle of r, and become smaller as the interradial line is approached so that it is difficult to distinguish them except that the superomarginals are here larger than the dorsolateral plates (here actinal in position). The latter also become smaller on this actinal interradial portion of the disk, and the papulae are lacking proximad of the tenth superomarginal.

Between the first superomarginal and second adambulacral of each ray are 6 intermediate plates. Opposite the first adambulacral is a short series joining a couple of unpaired plates so as to form a Y-shaped group. A large plate just back of the mouth plates is embraced by the arms of the Y. Opposite the seventh inferomarginal are 2 intermediate plates in a transverse row. Opposite the sixteenth plate there is but a single plate between the inferomarginals and adambulacrals. This single longitudinal series persists to within about 12 mm. of the tip of ray. Between the first and seventh inferomarginals the number of plates in the transverse series decreases from 6 to 2. The whole actinal interradial area proper is very small, as half of the actinal surface of the disk is occupied by "abactinal" plates.

If a portion of the abactinal skeleton is denuded and cleared the irregular plates of the median portion of ray are seen to be mostly 3-lobed and very strongly but irregularly imbricated. The plates themselves are not of uniform size and scarcely 2 are of exactly the same shape. The dorsolateral plates, on the contrary, are regularly 4-lobed and the proximal longitudinally directed lobe overlies the corresponding distal lobe of the next plate adorad, while the transverse lobe directed toward the radial line overlaps the external lobe of the next plate. The dorsolateral papulae occupy singly the small interspaces and are consequently in regular longitudinal and transverse series.

Adambulacral plates small, close-set, with a slightly curved furrow margin. The adjacent actinal intermediate plate encroaches upon the surface which is usually a little longer than wide. Furrow spines proximally 5, the 3 median 3-sided or quadrate in section, round-tipped or truncate; the proximal and distal spines are shorter: usually the distal is about one-third or one-half as long as adjacent spine and the proximal about one-half or three-fourths. The first few plates usually have the spines more flattened at the end. Occasionally there are 6 spines and distally usually 5 or 4. Just back of the furrow spines (which stand upright) are 3 or 4 shorter spinelets with thicker ends, and back of these about 3 or 4 slightly smaller spines, which stand so near the actinal intermediate plate that it is difficult to determine sometimes to which plate they belong. The plates at about the middle of ray have 3 or 4 longitudinal series of spines, 2 or 3 in each series. The adambulacral spines are all blunt, very close-set, and they grade from the furrow spine into the actinal intermediate spines.

Mouth plates very small with nearly straight furrow margin bearing 5 to 7 compressed furrow spines with broad tips and edge to furrow, heavier than the adambulacral spines, and increasing slightly in length toward the inner angle. Behind these on each plate is a row of 4 or 5 smaller subambulacral spines which occupy about all of the remaining surface of the plate.

Madreporic body small, surrounded by 6 plates of which 1 on the adcentral side is largest, and situated slightly adcentral to the middle of r.

Superambulacral plates present. These are attached to the lower end of the ambulacral ossicles and the upper end is subtruncate and often broader than the lower, which is more or less rounded.

Type.—Cat. No. 32642, U.S.N.M.

Type-locality.—Station 5543, off Point Tagolo, northern Mindanao, 162 fathoms, sand; bottom temperature, 54.5° F.

Distribution.—Known only from the type-locality.

Family METRODIRIDAE Fisher.

Metrodirinae Sladen, 1889, p. 415.
Metrodiridae Fisher, 1917*d*, p. 171.

Diagnosis.—Whole skeleton overlaid by a rather thin skin partially obscuring the outlines of the plates; rays slender; abactinal plates tessellate, partly imbricated, with small spines; marginal plates large, forming side wall of ray, there being 1 or more series of intermarginal plates on the proximal part of ray; actinal intermediate plates reduced to one, between mouth plates and inferomarginals; papulae isolated, strictly abactinal; tube feet with sucking disk devoid of calcareous deposits; ampullae single; interbrachial septa rudimentary, practically absent.

Genus METRODIRA Gray.

Metrodira Gray, 1840, p. 282. Type, *Metrodira subulata* Gray.
Scaphaster de Loriol, 1899, p. 27, pl. 3, fig. 1. Type, *Scaphaster humberti* de Loriol.

This puzzling genus was placed in the Linckiidae by Sladen (1889, p. 415), and other authors have followed his lead.

It shows an outward resemblance to the Asteropidae, however, barring the single fact of the very slender rays. De Loriol (1899, p. 27) described a very young example as a new genus which he placed in the Gymnasteridae (=Asteropidae) near *Asteropsis* (=*Petricia*).

Sladen stated that "its external facies and general structure appear to indicate an intermediate position between the Linckiidae and Echinasteridae."

Unfortunately the specimens at my disposal are small. The characters which would lead one to place this genus in the Asteropidae (restricted to *Asterope* and *Petricia*) are as follows:

The thin skin which covers the plates and spines; the conspicuous marginals not unlike those of *Petricia;* the loosely tessellate abactinal skeleton, bearing skin-covered spinelets. The characters which are adverse, so to speak, are: The conspicuous series of intermarginal plates, the absence of actinal intermediate plates, except a single plate back of the mouth plates; the rudimentary interbrachial septum without a calcareous pillar (perhaps, however, due to small size of disk); the single ampulla to each tube foot.

The features which seem to ally *Metrodira* to the Echinasteridae are: The single ampullae, spinose abactinal plates, and the adambulacral armature. The intermarginal plates and the very reduced actinal intermediate areas are quite consistent with this family, but the very conspicuous marginal plates are not. The interbrachial septa are very rudimentary, practically absent, although it is not possible in the small specimens at my disposal to be certain of this point.

Beyond a certain similarity due to the outward form, particularly to the slender rays, the Linckiidae have little claim to this genus.

The presence of intermarginal plates and of single ampullae, and the absence of actinal intermediate plates and of interbrachial septa with calcified pillar will debar *Metrodira* from the Asteropidae, Ganeriidae, and Poraniidae, while additional differences in the abactinal skeleton make the last two families unsuitable homes.

Even the Echinasteridae appear to be incompatible. The abactinal plates of *Metrodira* are tessellated, not at all reticulate, while the marginal plates are large, compact, and form a vertical side to the ray. The interbrachial septa are almost lacking.

It seems better to place this genus in a separate family rather than to enlarge the Echinasteridae and in a measure spoil its homogeneity. The case of *Metrodira* is much like that of *Acanthaster*, *Mithrodia*, and *Valvaster*, which have at one time or another been in the Echinasteridae.

METRODIRA SUBULATA Gray.

Metrodira subulata GRAY, 1840, p. 282.—PERRIER, 1875, p. 180.—KOEHLER, 1910*a*, p. 172, pl. 4, figs. 1 and 2; pl. 18, fig. 9; 1910*b*, p. 284, pl. 15, fig. 3; pl. 17, fig. 3, 4, 5.

Scaphaster humberti DE LORIOL, 1899, p. 27, pl. 3, fig. 1.

Doctor Koehler[1] has given a detailed description and figures of this species. The Philippine examples, the larger measuring R. 25 mm., and r. 4 mm., are less spiny abactinally. The proximal plates of the intermarginal series are nearly as large as the adjacent inferomarginals, and there is usually an odd interradial intermarginal plate, but not an odd supero- or inferomarginal. The intermarginals extend about half the length of ray.

Type-locality.—Migupou (probably a Philippine locality).

Distribution.—Macclesfield Bank; Philippine Islands; Torres Strait; Aru; Amboina; northwest of Australia; northeast Australia; George Sound, New Zealand; Bay of Bengal; Ceylon.

Specimens examined.—Two from the following stations:

Station 5431, off Corandagos Island, eastern Palawan, 51 fathoms, sand.

Station 5432, same locality, depth, and bottom.

---

[1] Abhandl. Senckenberg. Naturf. Gescel., vol. 33, 1910, p. 284.

Family PORANIIDAE Perrier.

Poraniidae Perrier, 1894, pp. 163, 227.—Verrill, 1915, p. 68.
Asteropidae (*part*) Fisher, 1908, p. 90; 1911*d*, p. 247.—Verrill (*part*) 1914*a*, p. 304.

The family Asteropidae is restricted to *Asterope* and *Petricia* (*Asteropsis*), while the Poraniidae, which appears to be allied to the Asterinidae, includes the old genera *Dermasterias*, *Porania*, *Tylaster*, *Marginaster*, and *Poraniomorpha*[1] (including *Rhegaster* and *Lasiaster*) as well as the more recently defined genera: *Chondraster*[2] Verrill, *Culcitopsis*[2] Verrill, *Poranisca*[2] Verrill, *Poraniella*[2] Verrill.

Genus MARGINASTER Perrier.

Marginaster Perrier, 1881, p. 16. Type, *M. pectinatus*.

MARGINASTER PAUCISPINUS Fisher.

Plate 131, figs. 2, 2*a*.

Marginaster paucispinus Fisher, 1913*c*, p. 216.

Diagnosis.—Differing from *M. capreensis* (Gasco) [*M. fimbriatus* Sladen] in having no actinal intermediate and very few abactinal spinelets, broader marginal plates with slightly longer spines, more distinct lobes to the carinal plates, and 2 narrowly spatulate, webbed, subambulacral spinelets in a longitudinal series near the furrow margin; furrow spines 2 on the first 2 plates, then 1. R=11 mm., r=8 mm., general form arcuate pentagonal: whole body overlaid by skin; a few carinal, apical, and superomarginal spinelets, all inconspicuous; a conspicuous marginal fringe of webbed, flattened, narrowly spatulate spines; plates not superficially visible.

Description.—Abactinal plates obscured by the skin, which is smooth. Spinelets few. There is present a carinal series of short, clavate spinelets, about twice as long as broad, and few in number. Near center of disk these outline a rude star, and within this are a few small scattered almost granuliform spinelets. On either side of the ray there are a very few small spinelets.

The abactinal skeleton is revealed by immersion in weak caustic potash solution. In the arrangement of plates it is very similar to that of *M. capreensis*, figured by Ludwig (1897, pl. 7, figs. 13 to 23), but the plates themselves are slightly different in form. The skeleton is open, leaving large meshes or interspaces and is of the reticulate type. The center of disk is occupied by plates forming a conventional star, the tips of whose rays are the primary radial plates; the interradii are large five-lobed primary basal plates. The side of the rays of this star is formed by a long slender ossicle. Within the star is a pentagon of plates inclosing the central plate, which is attached to the pentagon by short connectives, and the corners of the pentagon are the basal plates. The carinal series consists of about 7 plates, the primary radial being elongate cordiform, the others prominently four-lobed, except the last 2 or 3, which are irregular. These imbricate so that a lobe extends laterally on either side. In contact with the prominent inferomarginals, which form a flange to the edge of ray, is a series of three-lobed superomarginal plates, which are connected with the lateral processes of the carinals by 1 or 2 (second and third carinals) slender ossicles. There are 7 superomarginals, and 5 of the transverse trabeculae, the last 2 superomarginals touching the reduced carinals (or sometimes the last lateral has no carinal opposite). Two slender ossicles end to end extend from the first superomarginal to the basal plate, close to the companion of the adjacent ray, so that the inner ossicles of each series touch along their whole length. These clasp the small madreporic body, which is on the outer lobe of a basal plate (Ludwig's JR1).

---

[1] Professor Verrill is in error in regarding *Rhegaster* as the oldest name for this group. *Poraniomorpha* dates from 1881 (Danielssen and Koren, Nyt. Mag. for Naturvidenskaberne, vol. 26, p. 189; type, *P. rosea*). *Rhegaster* Sladen was described in 1883 (Trans. Roy. Soc. Edin., vol. 32, p. 155: type, *Solaster tumidus* Stuxberg). *Lasiaster* Sladen dates from the *Challenger* Asteroidea (1889, p. 371, type *L. villosus*). See Verrill, 1914*b*, p. 17.

[2] For these genera, see Verrill, 1914*b*, pp. 17–21, and 1915, pp. 68–80. *Chondraster* was described originally as a subgenus of *Porania* (Amer. Journ. Sci., vol. 49, p. 137, type *Porania grandis*). The type of *Porania*, s. s., is *P. pulvilla* (O. F. Müller).

The inferomarginals, 7 in number, are much broader than long, flat, slightly spaced, with a curved border bearing 4 or 5 webbed, flattened narrowly spatulate spines as long as the base line of comb, the whole forming a flangelike ambitus. The outer end of the plate is slightly broader than the inner and the transverse margins are slightly concave. Parallel with the marginal series of spines and close to them on the upper surface of the plate is a series of 3 or 4 very small spinelets scarcely visible until specimen is treated with caustic potash.

Papular areas in 2 series on each ray, the outer being "intermarginal." The largest area is the proximal adradial, which has 8 or 9 papulae, while the others have 2, 3, or distally 1 papula. The larger areas have several white grains scattered in the integument.

The actinal intermediate plates are in general similar to Ludwig's figure 23. A series of oblong plates, one interradial, is adjacent to the inferomarginals. These are the largest intermediate plates. The largest, interradial in position, is scalloped on the inner border and constricted in the middle. The other 4 plates of each ray alternate with the inferomarginals and the outer end underlies the inner end of the marginals; moreover the plates are distinctly spaced. The other actinal intermediate plates are in transverse columns. Three columns start from the interradial and, by branching variably, have

3 or 4 branches touching the proximal 4 or 5 adambulacrals of each ray. From the second inferomarginal there are usually 2 short columns of 2 plates each, while the third and rudimentary fourth inferomarginals touch the adambulacrals. Conspicuous spaces exist between the columns of plates, the plates themselves being comparatively large and elongate cordiform or elongate ovate in form.

Adambulacral plates small, wider than long, and obliquely oriented. The first 2 plates have 2 small, blunt, slightly tapering furrow spinelets; the subsequent plates 1. Near the furrow margin in a longitudinal series are 2 webbed, narrow-spatulate truncate spinelets about as long as width of plate, and 1.5 the length of the furrow spinelets which they generally obscure by bending over furrow.

Mouth plates narrow with 4 furrow and 2 suboral spinelets similar to those of the adambulacral plates except that the inner furrow spine is larger.

Type.—Cat. No. 32641 U.S.N.M.

Type-locality.—State 5310, China Sea, vicinity of Hongkong (lat. 21° 31′ N.; long. 116° 13′ E.), 100 fathoms, sand, shells; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—This species resembes *M. capreensis* (Gasco) which Ludwig considers the same as the subsequenty described *M. fimbriatus* Sladen. In *M. paucispinus* there are few abactinal and no actinal intermediate spinelets, while in *capreensis* the former are abundant, and Sladen's figure (1889, pl. 58, fig. 5) shows a few actinal spinelets. The carinal plates of *M. paucispinus* have more prominent lobes than are figured by Ludwig, and the inferomarginal plates are much wider than long while the marginal spines are longer. In *M. capreensis* the 2 subambulacral spines are tapering, cylindrical and form a transverse series, while in *paucispinus* they are spatulate, flattened, and in a longitudinal series. In *M. pectinatus* Perrier, *M. echinulatus* Perrier, and *M. pentagonus* Perrier the subambulacrals are either in a transverse or an oblique series. The first has 1 furrow and 1 or 2 subambulacral spines; the second, 3 to 5 furrow and 2 or 3 subambulacral spines; the third, 1 furrow and 2 or 3 subambulacral in the same transverse series. *M. paucispinus* alone, therefore has the subambulacral spines in a longitudinal series.

Family ASTERINIDAE Gray, emended.

Genus ASTERINA Nardo.

Asterina NARDO, Oken's Isis, 1834, p. 716. Type, *A. minuta* Nardo=*A. gibbosa* (Perrier).—VERRILL, 1913, 477–485.

Professor Verrill has divided the old genus *Asterina* into the following genera:

Asterina; type, *A. gibbosa;* included species: *A. trochiscus* (Retzius).

Asterinides Verrill; type, *A. folium* (Lütken); included species: *A. cepheus* (Müller and Troschel), *A. wega* (Perrier), *A. minuta* (Linnaeus), *A. modesta* Verrill.

Patiria Gray, 1840; type, *P. coccinea* (Gray); included species: *P. miniata* (Brandt), *P. chilensis* (Lütken), *P. gayi* (Perrier), *P. granulosa* (Perrier), *P. pectinifera* (Müller and Troschel), *P. granifera* (Gray), *P. novae-zelandiae* (Perrier).

Patiriella Verrill; type *P. regularis* (Verrill); included species: *P. exigua* (Lamarck), *P. calcar* (Lamarck), *P. fimbriata* (Perrier), *P. squamata* (Perrier), *P. calcarata* (Perrier), *P. pusilla* (Perrier), *P. gunnii* (Gray).

Asterinopsis Verrill; type, *A. penicillaris* (Lamarck); included species: *A. pilosa* (Perrier), *A. lymani* (Perrier).

Enoplopatiria Verrill; type, *E. marginata* (Hupé) = *A. stellifera* (Möbius) = *A. braziliensis* (Lütken) = *A. minuta* (Müller and Troschel, not Linnaeus).

I have examined one or more representatives of these groups. Professor Verrill in his synopsis (p. 479) relies upon the absence of pedicellariae to distinguish *Asterinides* from *Asterina* and *Patiria* from *Enoplopatiria.*

I do not think that the pedicellariae form a reliable generic character in this family. They are absent in *Asterina coronata cristata* and present in *Asterina coronata euerces.* Relying upon the abactinal skeleton and spines I find it very difficult to separate *Asterinides* from *Asterina.* The ventral genital pores of *Asterina gibbosa*, if restricted to that species, are certainly an important character, but in practice it is often very difficult or impossible to find them. *Asterina,* as used in this paper would include, therefore, Professor Verrill's *Asterinides*, and similarly I would unite *Patiria* and *Enoplopatiria.* Following Professor Verrill's table somewhat, the genera as herein used are contrasted as follows:

a^1. Abactinal plates of papular areas all of one kind, the exposed part usually roundish, elliptical, cordate, or shield-shaped, wholly or partly spinulose. Two-bladed pedicellariae present or absent__________________*Asterina.*

a^2. Abactinal plates of papular areas of 2 or more diverse kinds, the larger proximally arched or crescentic, and notched for passage of papulae; between these are groups of small ovate or pyriform ossicles inserted endwise, mostly bearing small roundish clusters of spinules.

- b^1. Actinal intermediate plates each with a fan-shaped group of 2 to 8 spines, usually webbed. Pedicellariae present or absent______________*Patiria.*
- b^2. Actinal intermediate plates each with 1 or sometimes 2 spines; fewer secondary abactinal ossicles than in *Patiria;* no pedicellariae__*Patiriella.*
- b^3. Actinal intermediate plates each with a fascicle of slender spines; pedicellariae, absent or present______________________________*Asterinopsis.*

ASTERINA CEPHEUS (Müller and Troschel).

Plate 115, fig. 4.

Asterina burtonii? Gray, 1840, p. 289.
Asteriscus cepheus Müller and Troschel, 1842, p. 41.
Asterina cepheus von Martens, 1866, p. 85.—De Loriol, 1885, p. 69, pl. 21, figs. 1 to 5.

Notes on Philippine specimens.—The largest specimen has the following dimensions: R=20 mm., r=8 mm., R=2.5 r. The spinelets are all rather longer than in de Loriol's figure.

Type-locality.—Batavia.

Distribution.—Red Sea, Indian Ocean (Zanzibar in the south. Nicobar Islands, Ceylon, Mergui at the north), Java, Philippines, Torres Strait, Australia, New Guinea, New Caledonia.

Specimens examined.—Five:

Tataan Pass, Simulac Island, coral reef; 2 specimens. Maricaban Island, off Batangas Bay, Luzon, shore; 3 specimens.

Remarks.—The type of *Asterina burtonii* has been lost, according to Professor Bell.[1] Although the name probably refers to this species, in the absence of an authentic specimen Gray's description is quite insufficient. It seems better to retain the well-known name so long as a reasonable doubt exists as to the identity of *burtonii*.

ASTERINA CORONATA CRISTATA Fisher.

Plate 115, fig. 3; plate 131, figs. 4 4*a*.

Asterina cristata Fisher, 1916*b*, p. 27.
Asterina coronata cristata Fisher, 1918, p. 111.

Diagnosis.—Related to *A. cepheus*, but with a variable number (30–55 to a ray) of the abactinal plates elevated and tubercular in form, and surmounted by 1 to 5 unequal, robust, pointed spines, the largest 4 or 5 times as long as the spinelets of the other plates, and many times greater in diameter; the other abactinal plates with 5 to 10 short, sharp spinelets in spaced groups situated usually on the adcentral border; these spinelets are tapering, slender, 3 or 4 times as long as the width of their base, and in each group are placed with the bases touching, the spinelets themselves radiating apart. In center of disk a poorly defined pentagon of elevated plates. At base of ray are 6 regular series of papulae on either side of a radial area of irregularly arranged pores, the two areas corresponding to regions of regularly and irregularly arranged plates. The plates of the regular lateral series (of which there are 10 at the base of ray) are arranged in quincunx and those of the papular areas are hollowed out or excavated on the mesial border for the papula which is overhung and evidently protected by the group of spinelets. In the radial area the slight hollow is on the adcentral border. Inferomarginal plates with a conspicuous tapered spine surrounded by smaller spinelets. Actinal intermediate plates with a group (not a comb) of 2 to 4, mostly 3, basally webbed spinelets. Furrow spines usually 6, webbed for about half their length, the 3 or 4 median conspicuously larger than the laterals; subambulacral spines usually 4, the 2 median much longer than the laterals (in the cotype there are 5 or 6, of which 2 are enlarged). Oral spines 5, webbed, the 2 innermost conspicuously enlarged; suboral spines 3 to 5, upright, webbed, 2 of them of predominant size. Rays 5, rather narrow, longer than usual, and with a rounded extremity. R=37 mm., r=14.5 mm., R=2.5 r; breadth of ray at base, 15 mm.

---

[1] Bell, 1884, p. 131; Perrier, 1875, p. 316 (unable to find type).

Type.—No. 689, Museum of Comparative Zoölogy, Cambridge, Massachusetts.

Type-locality.—Ponape, Caroline Islands.

Distribution.—Caroline Islands.

Remarks.—The number of protuberances probably varies somewhat with age and local conditions. In the cotype, which has R, 25 mm., they are fewer.

In the Archiv für Naturgeschichte (vol. 32, 1866, p. 73), von Martens describes *Asterina coronata* from Batjan, Molucca Islands, and from Larentuka, Flores Island, and records its occurrence at Amboina. His description states that the relation of the minor to the major radius is as 1 to 2 or 2⅓, that the abactinal plates are so arranged that the dorsal surface has a honeycombed appearance, the plates bearing 5 or more spinelets, and that scattered over the dorsal surface are groups of 2 to 4 heavy spinelets with a common base, such groups being found on the sides and radial regions of the ray, but not close to the border. On the disk these special spinelets outline an irregular pentagon.

The elevated specialized abactinal plates of *cristata*, with their tuft of enlarged spines, I take to be the same as von Martens's "Büschel von 2–4 starken Stacheln mit gemeinsamer Basis," which he says, "stehen auf den Armen ziemlich zerstreut, sowohl auf dem Rücken als an den Seiten, aber nie ganz nahe am Rande." Thus the chief character of the two species is the same. As Dr. H. L. Clark has suggested in a letter, the two species are probably the same, although there exist certain discrepancies. Von Martens does not mention subambulacral spines, but states that the furrow-spines are "in einer Reihe, 4 oder 5 fast gleich Grosse auf jeder Platte," and that the actinal intermediate plates have 2 relatively long sharp spines. The type of *Asterina cristata* has 2 to 4, mostly 3, actinal intermediate spinelets, usually 6 furrow-spinelets webbed for about half their length, the 3 or 4 median conspicuously longer than the laterals, and usually 4 subambulacral spinelets, of which the 2 median are much longer than the laterals. I think it is possible that von Martens overlooked the small lateral furrow-spinelets, although not likely; but certainly in no specimens seen by me are the furrow-spinelets ever subequal.

The case is somewhat complicated by 2 specimens of a race of *coronata* which I saw some years ago in the British Museum. One was contained in a box with *Nepanthia maculata*, labeled "Migupou, 7 to 12 fathoms, fine sand coral—Cuming." The other was labeled "Port Essington, Australia." In the first specimen there are 20 or 25 of the prominent plates to each fifth of the body. The actinal intermediate plates have, in the neighborhood of the furrow, about 5 or 6 spines in a rude circle, one spine being longer than the others; near the ambitus there are 3 spinelets, with often 1 or 2 standing mesad from the principal comb. The furrow-spinelets are 5 or 6 webbed, the laterals shorter than the mesial spinelets; the subambulacral spinelets are 4 or 5, shorter and stouter than the furrow-spinelets, and also graduated in size, the mesial spinelets being longest. I made no notes on the Australian specimen, but my impression is that it does not materially differ from the other.[1]

Thus the actinal intermediate spinelets are more numerous than in the types of *coronata* and *cristata*, while the adambulacral armature is about the same as that of *cristata*. The prominent abactinal plates are fewer than in *cristata*, and more like the condition in Japanese specimens.

Dr. Seitaro Goto, in his work on Japanese Asteroidea, carefully figures and describes a species from the southern parts of Kyushu and adjacent islands which he calls *Asterina novae-zelandiae*, Perrier, but which I believe is a form of *coronata*, as it possesses the prominent abactinal plates so characteristic of *coronata*. Thus there are records from southern Japan to northern Australia.

As a beginning towards straightening the tangle of apparent races, I would suggest the subjoined scheme. Any further evidence for or against it or in any way bearing upon the status of *Asterina coronata*, will be most welcome:

a^1. Abactinal spiniform pedicellariae present; 2 adambulacral furrow spinelets; 8 or 9 marginal mouth spinelets; 12 to 14 enlarged abactinal plates________________*Asterina coronata cucrces* (Fisher). (Palawan.)

a^2. No spiniform pedicellariae present; furrow spinelets 4 to 6; marginal mouth spinelets 5 or 6.

---

[1] For the privilege of examining these and many other specimens of Asteroidea in the British Museum (Natural History) I am indebted to Prof. F. Jeffrey Bell.

b^1. Actinal intermediate spinelets usually more than 3; near the furrow 5 or 6, forming a circle or group (not a tsraight comb); furrow spinelets 5 or 6; 20 to 25 prominent abactinal plates to each fifth of body,
Asterina coronata fascicularis Fisher[1] (Migupou; Port Essington?)

b^2. Actinal intermediate spinelets 2 or 3, but not often 4.

c^1. Furrow spinelets 4 or 5; actinal intermediate spinelets usually 2; prominent abactinal plates moderate in number (up to 25 to each fifth of body) and with as many as 25 spinelets to a plate.[2]
Asterina coronata coronata, von Martens. (Southern Japan, Batjan, Larentuka.)

c^2. Furrow spinelets 6; actinal intermediate spinelets usually 3 (2 to 4); prominent abactinal plates numerous (more than 30 and as many as 50 to each fifth of body) and with not more than 15 spinelets to a plate, frequently 10 or less.
Asterina coronata cristata (Fisher). (Caroline Islands.)

Prof. A. E. Verrill in his Revision of the Genera of Starfishes of the Subfamily Asterininae (1913, pp. 479, 480) gives primary importance to abactinal pedicellariae in distinguishing two of his new generic groups. The presence of pedicellariae abundantly in the Palawan race and their absence in Japanese and Caroline Island specimens show the character to be unreliable for generic distinctions. Of course, I recall that in the case of *Asterina* Professor Verrill has pointed out that the type, *A. gibbosa*, has the gonoducts opening just back of the mouth plates. If this character is confined to the restricted *Asterina* it will furnish a very important additional feature.

ASTERINA CORONATA EUERCES Fisher.

Plate 115, figs. 1, 2; plate 116, figs. 1, 2; plate 131, figs. 5, 5*a*.

Asterina cristata euerces FISHER 1917*b*, p. 91.
Asterina coronata euerces FISHER, 1918, p. 110.

Diagnosis.—Very close to typical *A. coronata cristata* but differing in having abactinal, spiniform pedicellariae, only 12 to 14 swollen abactinal plates to a ray, 8 furrow spines, and 8 or 9 marginal mouth spines. R=20 mm., r=9 mm., R=2.2 r; breadth of ray at base, 10 mm.

---

[1] Fisher, 1918, p. 110. This new race is certainly different as regards the actinal intermediate armature. Von Martens states that there are two spinelets in *coronata*. Of course, specimens may prove to be variable.

Mr. Alvin Seale, of the Museum of Comparative Zoology, who has lived many years in the Philippine Islands, tells me he has sailed past a fairly well-known *Migupou Point;* but I have not been able to locate it, with available maps, on Mindanao or on Luzon. Mr. Seale does not recall upon which of the two islands the point is found. It is quite possible that this is the locality from which so many of Gray's types were derived.

[2] So far as true *coronata* is concerned, the remarks concerning the number of prominent plates and the number of spinelets on these plates are conjectural. These observations refer to the Japanese form, described and figured by Dr. S. Goto ("A Descriptive Monograph of Japanese Asteroidea," 1914, p. 650, pl. 19, figs 279–281), which may, of course, be quite distinct from typical *coronata* of the Moluccan region. There are indications that a second race of this species, apparently distinct from *cristata*, is found in Japanese waters. In the Museum of Comparative Zoölogy is a specimen labeled as from Japan with only about 5 prominent abactinal plates to the ray, 6 furrow spines, 5 to 7 subambulacral spines (2 enlarged), and 3 to 5 actinal intermediate spines. The spinelets of the ordinary abactinal plates are shorter than in either *cristata* or *euerces*. It would seem to fit in near *fascicularis*.

Description.—Abactinal plates tilted obliquely as in the typical form so that the papular pore is at the bottom of a funnel-shaped depression, somewhat overhung on the abcentral side by a crescentic group of upward of 15 or 16 slender, tapering, sharp spinelets 3 to 5 times as long as their width at base. Plates arranged as in typical form, but with a well-developed pentagon of elevated plates in the center of disk, inclosing an apical area containing about 28 small plates having each 1 to 10 spinelets. On each median radial area 12 to 14 plates in an irregular double series (or scattered) are much higher and more prominent than the others, and bear a conspicuous tuft of spinelets, which increase rapidly in length toward the middle of the plate where there are 3 to 5 tapering sharp spines much larger than the others. The spinelets of the other plates are in more or less crescentic groups on the radial regions at base of ray, and on disk outside of the apical area, but only a part of them are so formed on the distal portion of ray. On the lateral areas of ray where the plates are arranged in regular series the groups are fasciculate, and are not crescentic except sometimes on the innermost of the regular series.

Numerous plates bear, on the concave side adjacent to a papular pore, a simple pedicellaria consisting of 2 to 4 sharp spinelets slightly stouter than the rest. These resemble somewhat the fasciculate pedicellariae of *Pectinaster*. Papular pores in about 4 regular series on either side of the median radial area; over the latter they are, at least proximally, arranged in quincunx but not very regularly; about 5 pores can be counted across it at base of ray.

Inferomarginal plates rather prominent, forming a narrow flange, the outer end of the plates bearing a double or a triple series of spinelets, or a tuft, the central being much the largest. The plates are relatively more prominent than in *A. cepheus*.

Actinal intermediate plates in 7 chevrons; 2 longitudinal series practically reach the tip of ray, while a third very nearly reaches it; a fourth extends two-thirds the length, measured along side, and a fifth about one-third. The plates bear 3 to 5 spines, webbed for about half their length. When there are more than 3 they form a fascicular group; when 3 are present they form a single series.

Furrow spines slender, scarcely tapered, 8 or occasionally 9, united by membrane nearly to the tip, and forming a scoop-shaped fan. The 5 central spines are of nearly equal length, and 1 aboral is only about half as long, while 2 adoral spines are successively two-thirds and one-third the length of the central spines. Subambulacral spines 6, united by membrane, the median 2 or 3 tapering, pointed, much heavier than the laterals, and much stouter than the furrow spines and adjacent actinal intermediate spines. When expanded these spines form also a scoop-shaped or concave fan lying over the furrow series. Usually, however, they are bent upward and form a group.

Mouth plates with a marginal series of 8 or 9 spines, increasing very gradually in size toward the innermost, and all united by membrane. On the outer part of the plate is a suboral fan of 5 or 6 spines on a slight eminence. These stand parallel to the margin adjacent to first adambulacral, and the inner end of the series bends inward toward the median suture, sometimes inclosing a single spine.

Madreporic body situated just external to the ring of raised apical plates and with 2 spines on the convex irregularly pitted surface.

Type.—Cat. No. 37036, U.S.N.M.

Type-locality.—Ulugan Bay (near mouth of Baheli River) Palawan Island, 2 to 5 feet, mud, sand, seaweeds.

Distribution.—Known only from the type-locality.

Remarks.—The following differences are observable between *Asterina coronata cristata* and *A. coronata euerces.*

Asterina coronata cristata.	*Asterina coronata euerces.*
Nonprominent abactinal plates with usually only 5 to 10 spinelets on the radial region of ray.	Nonprominent abactinal plates with usually 10 to 15 spinelets on the radial region of ray.
No abactinal pedicellariae.	Numerous abactinal spiniform pedicellariae.
Actinal plates adjacent to adambulacral plates with 2, 3, or 4 spinelets (regularly 4 on cotype, which has R, 25 mm.)	Actinal plates adjacent to adambulacral plates with 4, 5, or 6 spinelets—usually 5.
Furrow spines usually 6, sometimes 7.	Furrow spines 8, sometimes 9.
Subambulacral spines 4, the 2 median much enlarged (in the cotype 5 or 6, the 2 median enlarged).	Subambulacral spines 6, the 2 median not so much enlarged as in *cristata.*
Marginal mouth spines 5.	Marginal mouth spines 8 or 9.

Genus PATIRIELLA Verrill.

Patiriella VERRILL, 1913, pp. 480, 483. Type, *Asterina regularis* Verrill.

PATIRIELLA EXIGUA (Lamarck).

Plate 109, figs. 3, 4.

Asterias exigua LAMARCK, 1816, p. 554.

Asterina exigua PERRIER, 1875, p. 302.—KOEHLER, 1910*a*, p. 129, pl. 9, figs. 6 and 7.

Notes on Philippine specimens.—The largest example has the following dimensions: R=20 mm., r=14 mm. There are a considerable number of six-rayed specimens, and a very few four-rayed. The papulae are restricted to the disk and a rather broad petaloid area on the radii comprising about a dozen longitudinal series. On the interradial line the papulae extend a little more than one-half r toward the margin. Outside the papular area the plates carry 7 to 10 relatively coarse, thimble-shaped granules in a group. On the papular areas the granules are also few, slightly spaced, and about 7 to 12 in number. Adambulacral spines: Two on edge of furrow (3 may occur on first few plates) and 1 much coarser subambulacral spine. Between the base of latter and first row of actinal intermediate spines is a conspicuous naked space. Actinal intermediate spines 1 to a plate, and lacking on a small area back of the mouth plates.

Type-locality.—Unknown.

Distribution.—Cape of Good Hope, Madagascar, Mauritius, Andaman, and Nicobar Islands, Java, Moluccas, Philippines, south and east Australia.

Specimens examined.—One hundred and one:

Maricaban Island, off Batangas Bay, Luzon, shore; 55 specimens.
Port Binanga, Subic Bay, Luzon; 14 specimens.
Besoga, Luzon; 4 specimens.
Jamelo Bay, Luzon; 1 specimen.
Mantaquin Bay, eastern Palawan, sand; 5 specimens.
Panbutan Bay, western Mindanao, reef; 1 specimen.
Little Santa Cruz Island, Zamboanga, Mindanao; 1 specimen.
Babuan Island, Jolo, coral reef; 8 specimens.
Pangasinan Island, Jolo; 1 specimen.
Tataan, Tawi Tawi Group, Sulu Archipelago, shore; 1 specimen.
Sandakan, Borneo, beach; 7 specimens.
No label, 3 specimens.

Genus ASTERINOPSIS Verrill.

Asterinopsis Verrill, 1913, p. 480. Type, *Asterina penicillaris* (Lamarck).

The following species is by no means typical. There are very few secondary abactinal ossicles and there are small abactinal spiniform pedicellariae. It is apparently related to *Paranepanthia.*

ASTERINOPSIS PEDICELLARIS (Fisher).

Plate 114, figs. 2, 3; plate 121, fig. 1; plate 132, figs. 2, 2*a*.

Nepanthia pedicellaris Fisher, 1913*c*, p. 217.

Diagnosis.—Rays 6; R = 22 mm., r = 8 mm., R = 2.75 r; breadth of ray at base, 7 or 8 mm.; abactinal surface arched, actinal surface plane; rays tapering, bluntly pointed; radial area of crescentic plates proportionately very broad and not clearly marked off from the lateral areas which at base of ray are only about 5 plates broad, these being subcircular pseudopaxillae; larger crescent plates bearing 35 to 45 minute, sharp spinelets, and sometimes a simple pedicellaria composed of 2 spinelets stouter than the others, furrow spines 6 or 7 webbed, the adoral much the smaller; subambulacral spines webbed, 8 to 12; proximal actinal intermediate plates with 7 to 9 slender, webbed spines.

Description.—Abactinal plates crescentic, those of disk not regularly arranged; along median radial region is an area 6 or 7 plates wide where the plates are arranged in quincunx with sometimes a small roundish plate in the concavity of the crescent; then on either side are regular longitudinal series of plates, about 10 at the base of ray and 3 to 5 at the tip, which meet the superomarginal series obliquely. Near the margin, forming an area 5 plates wide at base of ray, the plates are in transverse series (between the outermost oblique longitudinal series of crescentric plates and the ambitus), are elliptic or quadrate in form, have no papulae between them, and bear subcircular groups of radiating spinelets. The crescentic plates bear 35 to 45 very delicate sharp spinelets and have a papula on the concave side.

There is no lateral flange. The superomarginal plates are clearly distinguishable and are about the same size as the small adjacent abactinal plates, while the inferomarginals are considerably larger, are set obliquely, and bear an elliptical group of numerous fine spinelets.

On either side of the interradial line 9 actinal intermediate plates can be counted between the adambulacral plates and margin. The series opposite the first and second adambulacrals do not reach the margin, while the third is complete. The plates also form longitudinal series, 4 extending to the middle of ray, but only 1 attaining the tip. The proximal plates bear 7 to 9 slender, slightly tapering, pointed spines united for half their width by membrane; the smaller plates bear 6 or 7 spines. The spines form a group rather than 2 series, as it frequently happens that 5 to 8 spines form a circle around a central spine, and all flare apart, more or less, but are nevertheless directed toward the margin.

Furrow spines 6 or 7, slender, very slightly tapering, blunt, and webbed for nearly their whole length. The adoral spine is quite short; the next is half again as long, the third about twice as long as the first, the fourth and fifth each slightly longer than the preceding; the sixth about equal to the fifth. When there are 7, the last spine about equals the third. Subambulacral spines 8 to 12. There is a semicircular webbed series parallel in general to the furrow series, consisting of about 8 (as many as 10) spines increasing in length from the short adoral to the fifth or sixth, then decreasing, the last spine being longer than the first, unless there are 10, when the series is symmetrical. Often 1 or 2 spines stand in the hollow of this series segregated from the others. The subambulacral spines are a trifle stouter and are more acute than the others.

The oral armature is of the same character as the adambulacral. Marginal spines about 9, slender, untapered, blunt, the inner 3 or 4 being the stoutest. Subambulacral spines about 12, sharp, and arranged parallel to the others, increasing in length from the outer to the inner.

Incipient pedicellariae are present on the abactinal surface. These consist of 2 spinelets stouter than the rest, which meet over the hollow of a strongly crescentic plate, the spines standing on the concave edge of the plate near either end. They are thus either over or close to the papula. Pedicellariae are rare in this family.

Madreporic body small and on account of the encroachment of 3 plates is trilobate. It is situated about one-third r from center.

Type.—Cat. No. 32643, U.S.N.M.

Type-locality.—Station 5482, off Cabugan Grande Island, Surigao Strait, east of Leyte, 67 fathoms, broken shells, stones, green mud.

Distribution.—Known only from type-locality.

Remarks.—The classification of this species has given considerable trouble. It resembles both *Parasterina* and *Asterinopsis*. I have placed it in the latter group because the papulae extend nearly to the margin and there is no sharply defined radial area of irregular abactinal plates. The actinal intermediate spinelets are in fascicles, and the adambulacral armature is sufficiently near that of *Asterinopsis penicillaris* in plan, although the spinelets are more numerous in *pedicellaris*. There are, however, very few secondary abactinal ossicles, and there are small spiniform pedicellariae present. The gap between *Asterinopsis* and *Paranepanthia* is not great.

Although this species resembles *Nepanthia brachiata* Koehler, I think that species is nearer *platydisca* and a *Paranepanthia*.

Genus PARANEPANTHIA Fisher.

Paranepanthia FISHER, 1917*e*, p. 172. Type, *Nepanthia platydisca* Fisher.

Diagnosis.—Similar to *Asterina* in form, but with the adambulacral armature of *Nepanthia;* actinal intermediate plates in transverse series, and bearing a tuft of spinelets which becomes compressed and pectinate toward the margin of disk; bases of these spinelets webbed; abactinal plates imbricated, divided into 2 areas: On center of disk and along a radial band they are rather crescentic with a few smaller plates intermingled (usually placed adorad to the hollow of the crescent); while between this area and the ambitus the plates lack the crescentic form and are arranged in transverse series. Superficially the plates resemble low parapaxillae, as they bear truncate groups of slender spinelets.

Remarks.—This genus is distinguished from *Asterina*, in the wider sense, by the sharp differentiation of the plates of the center of disk and radial areas from those of the lateral portion of the abactinal surface; by having an adambulacral armature of the *Nepanthia* type, though less extreme than that of *maculata*; and by the arrangement of the actinal intermediate plates which are not in chevrons, in the ordinary sense, but form transverse series, separated by shallow grooves, proceeding from the adambulacrals to the ambitus. The first few series do not reach the ambitus, but end rather irregularly on the inner half of the interradial line. This may be true to a certain extent in *Asterina*, but its plates, as in *Nepanthia*, form series more obviously parallel to the adambulacral series. In *Paranepanthia* the spinelets of the actinal intermediate plates are in bunches or tufts near the furrow but pectinate toward the margin. *Nepanthia* differs in having the rays slender and cylindrical, or narrow, flattened actinally and arched abactinally (hemicylindrical) with a correspondingly narrowed actinal intermediate area, the plates of which have numerous short spinelets like the abactinal plates.

Callopatiria Verrill[1] differs in lacking the differentiation of the abactinal plates into 2 areas, in having the adambulacral armature more nearly like that of *Asterina*, and in having many small secondary abactinal plates.

Paranepanthia seems to me to include *N. brachiata* Koehler (1910*a*, p. 133), a six-rayed species from the Andaman Islands.

PARANEPANTHIA PLATYDISCA (Fisher).

Plate 114, figs 1, 4; plate 116, figs. 4, 5; plate 132, figs. 1, 1*a*–*b*.

Nepanthia platydisca FISHER, 1913*c*, p. 218.

Diagnosis.—Rays 5; R=54 mm., r=23 mm., R=2.3 r; breadth of ray at base, 36 mm.; interbrachia rounded, rays tapering evenly from base to bluntly pointed extremity; general form much flattened and resembling an *Asterina* with thin disk; edges of disk and ray thin; abactinal plates divided into 2 areas, a median radial, where the plates are irregularly distributed, and lateral areas, where the plates form transverse (and also to some extent longitudinal) series, the transverse with about 26 or 27 plates at base of ray; plates resembling small flat-topped pseudopaxillae; actinal intermediate plates small, in transverse series, the larger plates with 15 to 20 slender, very sharp, webbed spines; furrow spines 7 or 8, webbed into a very convex fan; subambulacral spines 12 to 20, also webbed.

Description.—The general form is flat, the body being thin, much as in *Anseropoda*. The radial areas of irregularly arranged plates are sharply marked off and their width at base of ray is about one-half r, while on the interradial line they occupy a trifle more than one-half r. Between the margin of the median area and the ambitus extend transverse series of small elliptical plates, which also, on the adradial half or two-thirds of this area, form longitudinal series. The transverse series sometimes bifurcate at the outer ends, and the plates of each series decrease regularly in size toward the ambitus. In a complete series reaching the margin at middle of interbrachium about 26 or 27 plates are present, while at the middle of ray about 17 or 18 can be counted. These plates are roundish or broadly elliptical and overlap strongly. They bear elliptical groups of short papilliform spinelets, about 10 on the small plates and 20 or 25 on the larger. On the median radial areas and central portion of disk the plates are of several sizes, especially at base of ray. They are small and roundish or larger and crescentic or elliptical. On the distal part of ray nearly all the plates are small and bear a roundish group of 10 to 18 very short spinelets, while the larger bear 25 to 35. These groups of spinelets are distinctly spaced and resemble, along with those of the lateral areas, low parapaxillae or pseudopaxillae. Papulae are scattered over the area of irregular plates and extend about two-thirds the length of ray, but are not present on the lateral areas.

---

[1] *Callopatiria* Verrill, May, 1913; type, *Patiria bellula* Sladen. Amer. Journ. Sci., vol. 35, p. 480.

The marginal plates are very small. The inferomarginals define the ambitus, while the subequal superomarginals are abactinal in position.

The actinal intermediate areas are broad, the plates forming well-marked transverse series, the plates decreasing gradually in size toward the ambitus, where they are very small. In the first complete series, at base of ray, are 35 plates; at the middle of ray there are 20. The larger plates bear about 15 to 20 slender, very sharp spinelets about 1 mm. long and webbed into a circular group. Usually, however, they are bent toward the ambitus and form a double series, one covered up by the other. The combs of one plate overlie the base of the spines of the next plate toward the margin. Sometimes the spinelets stand more erect, and then the combs of a series do not imbricate. The transverse series are separated by shallow well-marked grooves.

Furrow spines 7 or 8 slender, untapered, blunt, united by a web into a fan-shaped group with a strongly convex distal margin. The adoral spine is usually short, about equal to base line of comb in length. The next 2 are increasingly longer, the next 3, subequal, and the last slightly shorter; or where there are 8 the last is nearly as short as the first. Subambulacral spines proximally 18 to 20, but distally only about 12. They usually stand erect, are webbed, and in favorable places may be seen to form a very convex series, with 6 or 8 spines in the concavity of the series, and involved in the same membrane. Sometimes there is an appearance of 2 concentric series with several irregularly disposed spines externally.

Mouth plates with 11 or 12 marginal spines, increasing in length toward the inner end of series, the companion series united by a common web. Suboral spines 20 to 25, in 2 series, parallel to free margin, with 5 or 6 extra spines between the second series and the median suture. The first series contains 7 or 8 spines increasing in length toward the median suture. The second, less regular, contains 5 or 6 spines.

Madreporic body medium-sized, situated one-third r from center. It is roughly 3-sided and surrounded by several plates larger than the neighboring abactinal plates.

Type.—Cat. No. 32644, U. S. N. M.

Type-locality.—Station 5645, Buton Strait, Celebes, 206 fathoms, bottom not recorded; 1 specimen.

Distribution.—Known only from type-locality.

Genus NEPANTHIA Gray.

Nepanthia Gray, 1840, p. 287. Type, *N. maculata* Gray.

KEY TO THE SPECIES OF NEPANTHIA HEREIN DESCRIBED.

a^1. Rays 5, marginal plates small, not defining ambitus, actinal surface convex, ray cylindrical ---------- *maculata*, p. 422.

a^2. Rays 5 to 7; inferomarginal plates conspicuous, defining ambitus; actinal surface subplane, abactinal surface convex ---------- *joubini*, p. 423.

NEPANTHIA MACULATA Gray.

Plate 113, figs. 3, 4.

Nepanthia maculata Gray, 1840, p. 287.—Perrier, 1875, p. 322.—Sladen, 1889, p. 388, pl. 64, figs. 1–4.

Notes on Philippine specimens.—It is not possible to be certain whether these specimens are really *N. maculata* or a closely allied species. They present some points of difference from Sladen's figures, and, as he states, the few descriptions are rather vague. In the largest specimen R=50 mm., r=8 mm.; R=6.25 r; breadth of ray at base 9 mm.

The differences which these specimens present when compared with Sladen's plate will be noted. The form of the ray is practically the same. The abactinal area of crescentiform plates shows this difference, that the little plate just adorad to each papula, as clearly shown in Sladen's figure 3, is lacking in all the *Albatross* examples. This median area is about 6 to 8 plates wide, counting along an oblique series (as in Sladen's figure). Then come on either side between the crescentic plates and the inferomarginals, at base of ray, about 6 longitudinal series of superficially rectangular plates, the plates of the outer 2 series being smaller than the others. Then, counting toward the furrow and including the inferomarginal series, 5 series of plates (close to interbrachium 7 series) the plates of the 2 inner series much larger than those of the outer 3 or 4.

The greatest difference is observable in regard to the disposition of the adambulacral spinelets. Sladen states that his figure 4 represents the spinelets in what he believes to be the natural posture and that this condition was found on only a few plates. In our specimens only the 2 innermost fans are clearly distinguishable, the spinelets on the outer part of the plate being less regular in arrangement, and similar in arrangement to those of *N. brevis*, although more numerous, as well as slenderer and more sharply pointed.

In 2 small specimens (R=14 mm.) which have the proportions of *N. brevis* but which are believed to be young of *maculata*, the armature is more as in Sladen's figure 4, although not quite so regular; and of the 2 specimens 1 has the armature more regular than the other. A peculiarity of these 2 specimens is the grouping of the spinelets of the abactinal crescentic plates in 3 or sometimes 2 distinct tufts to each plate. This gives the appearance of numerous small plates.

These small specimens are distinct from *N. brevis* and *N. suffarcinata*, and of course may represent a third species. Their affinities are close to *N. maculata.*

The largest specimen has 2 madreporic bodies. The others have one.

All the specimens are bleached yellowish, and unspotted.

Type-locality.—Migupou (Gray).

Distribution.—Philippine Islands; Arafura Sea.

Specimens examined.—Four.

Station 5157, off Tinakta Island, Tawi Tawi Group, Sulu Archipelago, 18 fathoms, fine sand; 1 specimen.

Station 5161, same locality, 16 fathoms, fine sand; 1 specimen.

Station 5335, Linapacan Strait, vicinity Linapacan Island, north end of Palawan, 46 fathoms, sand, mud; 2 small specimens.

NEPANTHIA JOUBINI Koehler.

Plate 113, figs. 1, 2.

Nepanthia joubini KOEHLER, Description d'une Astérie nouvelle (Nepanthia Joubini), provenant du cap Saint-Jacques (Cochin-chine). Bull. du mus. d' hist. naturelle, July 1908, No. 5, p. 232.

Notes on Philippine specimens.—The Leyte specimen is larger than Koehler's: R=32 mm., r=7 mm. There are 6 rays, 2 large ones opposite each other with a pair of small ones between on either side. There is only 1 madreporic body. The adambulacral armature greatly resembles Sladen's figure (1889, pl. 63, fig. 5) of that of *N. brevis.* In the furrow series are 7 webbed spines, the median the longest; the first subambulacral contains about 7 spines forming a very convex fan, parallel to the furrow series, while 3 to 5 spinelets stand just back of the subambulacral series and are invested by the same membrane. The plates of the median radial area are less regular than in Koehler's type, but the specimen is larger, which may account for the difference.

Numerous papulae are guarded by simple pedicellariae consisting of 2 to 4 sharp spinelets, which meet at a common point and resemble somewhat the fasciculate pedicellariae of *Pectinaster*. Similar pedicellariae are common in *Asterinopsis pedicellaris*.

The inferomarginal plates are larger than the others, longer than wide, and define the ambitus. I am in considerable doubt as to whether this specimen, which is regenerating 4 rays is not really a 6-rayed *N. brevis* Perrier.

The smaller specimen has perfectly regular abactinal plates.

Type-locality.—Cochin China (Cape St. Jacques).

Distribution.—Known only from the type-locality, from off Leyte (vicinity Surigao Strait), 57 fathoms, shells, and from near Jolo.

Specimens examined.—Station 5178, off Tacbuc Point, Leyte (vicinity of Surigao Strait), 57 fathoms, shells.

Marongas Island, north of Jolo, from a coral head, small specimen.

Genus ANSEROPODA Nardo.[1]

Anseropoda Nardo, Oken's Isis, 1837, p. 716. Type, *A. membranacea* (Retzius).

ANSEROPODA MACROPORA Fisher.

Plate 110, fig. 3; plate 131, figs. 3, 3*a–b*.

Anseropoda macropora Fisher, 1913*c*, p. 219.

Diagnosis.—Rays 5. R = 16 mm., r = 8.5 mm., R = slightly less than 2 r. Proportions and form variable; a four-rayed specimen has the following dimensions: R = 17.5 mm., r = 13 mm.; in the latter the margin of ray curves outward and has a broad leaflike contour. Species characterized by presence along radial line of a zigzag series of 7 to 11 wartlike conspicuous protuberances composed of 4 upright spinulate plates guarding a large papular pore; other abactinal plates with divaricate tuft of 8 to 12 very delicate spinelets; actinal intermediate area with spaced combs of 3 to 5 delicate sharp spinelets; furrow spinelets 5, webbed, the adoral set back slightly from margin; subambulacral spinelets 1 or 2, near adoral margin of plate.

Description.—Body very thin and raised only along the radial lines, where there are 7 to 11 large papular pores forming a zigzag series and each guarded by 4 plates, the edges of which are raised so as to form a little mound or wartlike protuberance. The free edges of the plates, bordering the relatively large pore, are semicircular and the free surface of the plate is nearly perpendicular. These plates are covered with numerous short, terete, delicate, blunt spinelets, which guard the pore, and also extend part way down the sides of the plates, which appear to be slightly movable. The single papula is large. The other abactinal plates are arranged in very definite series parallel to the interradial line, and in the four-rayed cotype they also form longitudinal series parallel to the radial line. This is true also of the type but the longitudinal series are less evident. The dorsolateral plates bear a tuft of 8 to 12 radiating, slightly spaced, very delicate terete spinelets, either blunt with several fine points, or slightly tapered and sharp. These groups are spaced about one-half their own diameter and the spinelets are considerably smaller than those of the pore-plates. The marginal plates are very small with a marginal fringe of small spinelets.

---

[1] *Carna* Gistel, Naturgeschichte des Thierreichs, 1848, p. 176. Type, *Asterias membranacea*.

Actinal intermediate plates in very definite series leading from the furrow to margin and also in series parallel to furrow. Each plate has a comb of 4 or 5 very delicate, sharp, spinelets becoming reduced to 3 distally and toward the margin. The median spinelet is the longest, and slightly overlaps the base of the next comb toward margin.

Furrow spinelets 5, webbed, very slender and delicate, pointed, the adoral set back from the margin slightly and about two-thirds or three-fourths the length of the others, which are subequal, and about twice as long as the base line of the comb. Back of the adoral spinelet near the transverse margin are proximally 2 shorter, slender, subambulacral spinelets, becoming 1 distally, and disappearing near end of ray.

Type.—Cat. No. 32645, U.S.N.M.

Type-locality.—Station 5146, Sulu Archipelago, off Sulade Island, southwest of Jolo, 24 fathoms, coral sand, shells: 2 specimens, 1 imperfect.

Distribution.—Known only from the type-locality.

Remarks.—This species belongs to the section of the genus in which there are few papular pores, in a single series on either side of the median radial line. Its distinguishing peculiarity is the specialization of these pores, which are guarded by elevated plates forming tubercular spinulate protuberances. The papulae themselves are large.

Anseropoda macropora is most nearly related, I think, to *A. petaloides* (Goto), Misaki, Japan. It also bears a considerable resemblance to *A. tenuis* (Goto), Misaki, Japan. (See Goto, 1914, pp. 656–662, pl. 19, figs. 282–285.)

ANSEROPODA, species

There is a fragment comprising the greater part of 1 ray, from station 5433, off Corandagos Island, eastern Palawan, green mud, coral sand. The species is new and resembles *A. diaphana* (Sladen) but is of a stouter habit apparently. It is not possible to be sure that there are 5 rays, as none of the disk is present. The species differs from *A. diaphana* in having more numerous spinelets in the abactinal tufts, much more numerous papular pores, these being arranged in 2 irregular, sometimes zigzag, series along either side of a narrow median radial area. The abactinal plates usually have, near base of ray and radius, 3 tufts of spinelets, of which the median is large and carries 12 to 20 delicate sharp spinelets, and the small lateral tufts only 2 to 5. Sometimes there is 1 small tuft. Near the margin, only the large tuft persists. The furrow spinelets are 6 or 7 (6 in *diaphana*). Subambulacral spinelets proximally 5, then 4, then 3. The median 1 or 2 are much the stoutest. Actinal intermediate spinelets 3 to 5, in a single series, basally webbed, the median 1 or 2 much the stoutest.

Sladen states that in *diaphana* the papular pores are large and spiraclelike, margined by 7 or more plates, each of which bears a small comb of rather elongate spinelets directed over the opening. In the present species the pores are margined by 3 to 5 plates. It is possible that on the disk there were more.

Family ECHINASTERIDAE Verrill (restricted).

Genus ECHINASTER Müller and Troschel.

Echinaster MÜLLER and TROSCHEL, 1840*a*, p. 102; 1840*b*, p. 321. Type, *Asterias seposita* Lamarck (not Retzius, 1783) =*Asterias sagena* Retzius, 1805, first species (designated, Fisher, 1913*b*).—FISHER, 1911*d*, p. 260; 1913*b*, p. 194.—VERRILL, 1914*a*, p. 206 (+*Othilia*); 1915, p. 35 (+*Othilia*).

Rhopia GRAY, 1840, p. 282. Type, *R. seposita* Gray=*A. sagena* Retzius, not *A. seposita* Retzius as stated by Gray (designated, Fisher 1913*b*).

The genus *Echinaster* Müller and Troschel (April, 1840) is usually understood to include *Othilia* and *Rhopia* Gray (December, 1840). In a key to the genera of Echinasteridae in Asteroidea of the North Pacific, etc. (1911, p. 259), I recognized *Othilia* for those species which have, in addition to abactinal papulae, also intermarginal papulae or both intermarginal and actinal papulae, while the name *Echinaster* by implication was reserved for *Echinaster sepositus* and allies, in which there are neither intermarginal nor actinal papulae.

Professor Verrill, in a letter, dissented from this course. I published a short note (1913*b*) in explanation of my point of view, which is here largely reproduced.

Professor Verrill considers that *Asterias spinosa* Retzius (1805),[1] which I made the type of *Othilia* Gray, is really the type of the previously described *Echinaster*, by designation (Müller and Troschel, 1842, p. 22, footnote). This would make *Othilia* a synonym of *Echinaster* Müller and Troschel. *Echinaster* would therefore be the correct name for the genus which I call *Othilia*, while the genus here called *Echinaster* would receive, as I pointed out in 1913, the name of *Rhopia* Gray. Verrill has since published his views (1914*a*, p. 207, 1915, p. 36) but appears not to have seen my note of 1913.

---

[1] This name is preoccupied by *Asterias spinosa* Pennant, 1777 [=*Asterias glacialis*, 1758]. *Asterias echinophora* Lamarck, 1816, is the tenable name for the species.

The distinction between the restricted *Echinaster* and *Othilia* may seem a trifle subtle. In practice, however, it has not been difficult to use the two groups—at least so far as species which I have personally examined are concerned. It may be noted that the same difference separates *Henricia* and *Cribraster*, the latter corresponding to *Echinaster*. The following notes will present my reasons for retaining the name *Othilia* for the American species.

The original description[1] of *Echinaster* is not accessible, but it was reprinted[2] in September of the same year in the Archiv für Naturgeschichte, with the following enumeration of species: "4 Arten: *A. sepitosa* Lam. [=*A. seposita*], *A. echinophora* Lam. (*Pentadactylosaster spinosus* Linck), *E. spongiosus* Nob. (Linck, t. 36, n. 62) und eine neue Art." As a footnote is the following: "*Echinaster* ist der älteste von Luidius und Petiver für ein hierher gehöriges Tier gebrauchte Name." There was no designation of type. Two years later in the System der Asteriden (p. 22), the species of *Echinaster* are cited in different order, namely: *spinosus*, *brasiliensis*, *crassus*, *gracilis*, *sepositus*, *fallax*, *eridanella*, *serpentarius*, *oculatus*, *eschrichtii*, *solaris*. In a footnote referring to *Echinaster*, the note quoted above is somewhat amplified as follows: "Ein von Luidius, Petiver und Linck zur Bezeichnung eines hierher gehörigen Tieres, *Asterias echinophora* Lam., angewandter Name." This seems to me to be not a designation of type but an explanation of the derivation of the new generic name, employed previously by Petiver in the following polynomial: "*Echinaster* seu stella coriacea pentadactyla echinata." *Asterias seposita* was given first place in the original description of *Echinaster* and it is reasonable to consider the European species as the type, as is very generally done when the genotype is in doubt.

Professor Verrill (1914*b*, p. 207) says: "The type of the latter [*Echinaster* Müller and Troschel] was *E. spinosus*=*Asterias echinophora* Lam., both by virtual tautology and by designation." As pointed out in the preceding paragraph, Müller and Troschel's "designation" is simply an explanation of the derivation of their name. The alleged tautology seems to me to be rather strained, inasmuch as *echinophora* was not a tenable name according to Müller and Troschel's views, and "*echinophora*" is certainly not "*Echinaster.*"

---

[1] Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, April, 1840, p. 102.

[2] Archiv f. Naturgesch. 6. Jahrg., vol. 1, p. 321.

As noted under the synonymy, *Rhopia Gray* (1840, p. 282) was founded upon two species, *Rhopia seposita* and *R. mediterranea*, the first of which I have already designated as type (1913*b*, p. 195). Gray states that *Rhopia seposita* is the same as *Asterias seposita* Retzius, 1783, and *Asterias seposita* Lamarck, 1816. He was apparently mistaken in regard to Retzius' species, which is said by Müller and Troschel (1842, p. 127) to be the same as the species now known as *Henricia sanguinolenta* (O. F. Müller, 1776). Lamarck's *A. seposita* originally included the species now called *Echinaster sepositus* and *Henricia sanguinolenta*, but was restricted to the former by Müller and Troschel (1842, p. 23, 126, but synonymy on p. 23 is corrected on p. 126 and 127). Gray must have had in mind the Mediterranean species for his type, because he had already made the true *Asterias seposita* of Retzius the type of *Henricia* under the name of *oculata* Pennant (1777) [this being antedated by *A. sanguinolenta* O. F. Müller, 1776]. Likewise his short diagnosis refers to *Echinaster* and not to *Henricia*, and the inclusion of *Rhopia mediterranea*, a synonym of *E. seposita* (Lamarck) indicates the group intended, namely, what I call *Echinaster*.

It is evident from the foregoing that the name *seposita* occurs under two different meanings. In any event the *Asterias seposita* of Lamarck is invalidated because it is a homonym of *A. seposita* Retzius, 1783. Now *A. seposita* Retzius is itself a synonym of *A. sanguinolenta* O. F. Müller, and is therefore shelved. In order to use *seposita* as the name of the Mediterranean *Echinaster*, it would be necessary to show that Retzius referred to this species. He did not refer to it, because his locality and description indicate *Henricia*, and he later described the *Echinaster* in question as *Asterias sagena* and *A. sanguinolenta* (Dissertatio, 1805, pp. 21, 22). Naturally the second of these names is rendered untenable by being a homonym of *A. sanguinolenta* O. F. Müller, 1776. But *Asterias sagena* is apparently available, and should be used in place of *seposita*. The type of *Echinaster* is therefore *Echinaster sagenus* (Retzius).

ECHINASTER CALLOSUS von Marenzeller.

Plate 112, fig. 2; plate 122, figs. 4, 5; plate 132, figs. 5, 5*a*–*c*.

Echinaster callosus VON MARENZELLER, Über eine neue Echinaster-Art von den Salomons-Inseln, Denk. k. Akad. Wiss. Wien, vol. 62, p. 531, 1 pl.—KOEHLER, 1910*a*, p. 174.

Notes on the specimens.—The largest specimen is larger than the type, having R=215 mm., r=22 mm., R=9.8 r. The disk is, therefore, as in the type, quite small, and the rays are a trifle swollen above the base, about as indicated in von Marenzeller's figure. This character is also present in a young specimen with R=42 mm.

I have examined the outer layer of the integument for the holothurianlike deposits described by von Marenzeller and find them present in the form of irregularly branched rods scattered irregularly and not crowded as in the following species. These rods are of variable size and form; sometimes the branches unite and form open lattice-plates with 1 to 5, or even more, unequal and irregular perforations. There are fewer perforated plates than rods. (See pl. 114, figs. 5, *5a–e*.

The young specimen is chiefly noteworthy in showing the double row of marginals much more clearly than the adult. In the interbrachial arc there are about a dozen small plates interpolated between the two series. The papular areas are sharply limited by the superomarginal plates, there being no intermarginal or actinal papulae. The same is true of the adult. What appear to represent the inferomarginal plates (in the young specimen) is a series of roughly elliptical or oval plates adjacent to the adambulacrals. Closely apposed to these is a similar series representing the superomarginals, but separated from them in the interbrachial arc. Immediately above the superomarginals the irregular mesh-work skeleton begins, so that there is really no other interpretation possible for these plates unless the superomarginal series is wanting. About every fourth or fifth superomarginal bears a stout conical spine, and about every fourth inferomarginal a similar spine, but the spines of the 2 series are not exactly opposite; they may even alternate. (See pl. 122, fig. 5.) Just external to the mouth plates and wedged between them and the first inferomarginal of each series is a prominent unpaired actinal intermediate plate bearing a spine. A rudimentary plate is present on either side of this. The presence of these plates pretty well establishes the identity of the inferomarginals. In the adult several additional plates are present on either side of the odd plate forming short series which do not extend beyond the sixth or seventh adambulacrals.

Type-locality.—Solomon Islands.

Distribution.—Solomon Islands; Celebes; Sulu Archipelago; Andaman Islands (Koehler).

Specimens examined.—Three:

Station 5138, vicinity of Jolo, 19 fathoms, sand and coral; 1 specimen (young).

Ligpo Point, Balayan Bay, Luzon; 1 specimen (adult).

Una Una Road, Binang Unang Island, Gulf of Tomini, Celebes; 1 specimen (large).

ECHINASTER STEREOSOMUS Fisher.

Plate 122, figs. 2, 3; plate 132, figs. 6, 6*a*–*e*.

Echinaster stereosomus FISHER, 1913*b*, p. 195.

Diagnosis.—Rays 5. R=52 mm., r=10 mm., R=5.2 r; breadth of ray at base, 12 mm. Disk fairly large; rays tapering at first rather rapidly, then very gradually, the distal two-thirds being attenuate; abactinal surface of rays well arched, actinal surface slightly convex. Spines short, conical, sharp, spaced 2 to 4 times their length, forming 2 marginal and proximally 5 (distally 3) abactinal, longitudinal series; papulae, 1 to 5 to each of the roundish, or more or less quadrate areas; no intermarginal or actinal papulae; skin fairly thick, covering everything except the tips of spines, and crowded with minute perforated plates and rods; a few true actinal intermediate plates present, all but 1 (which bears a spine) rudimentary; adambulacral armature a vertical series of 3 spines, the uppermost on border of furrow, the lower deep in furrow; upper spines with their membrane investment forming a continuous serrate web closing mouth of furrow. Related to *E. callosus*, but with larger disk, shorter rays broader at base, shorter spines, 3 adambulacral spines, and thinner skin, crowded with much more numerous, evenly distributed perforated plates of a different form.

Description.—Abactinal skeleton rather open, forming quadrate or roundish meshes, becoming elongate near end of ray. Most of the nodal points bear a short, stout, conical spine on an eminence of the plate. These spines form at base of ray 5 abactinal, 1 lateral, and 1 actinal series, the last two borne by the superomarginal and inferomarginal plates, respectively. The abactinal series adjacent to superomarginals ends at about the distal third of ray, so that beyond this point there are only 3 abactinal series of spines. The spines are well-spaced and proximally the abactinal series are sometimes rather irregular. The larger abactinal plates are three- or four-lobed and are connected proximally by a secondary ossicle (sometimes 2), three-lobed or subtriangular, oblong, or roundish. On the outer part of the ray 3 or 4 smaller, overlapping secondary plates may stand in a longitudinal series between 2 spine-bearing plates which are convex, while the connecting plates are not. The marginal plates form perfectly regular series. The inferomarginals have 4 rounded corners and are adjacent to the adambulacrals. The first 4 or 5 plates usually each bear a spine; beyond this point every third or fourth plate is spiniferous. The superomarginals are directly above the inferomarginals and leave only small skeletal spaces between. Near the base of ray the series turns upward as in other species of *Echinaster*, leaving a triangular space filled with about 3 series of small *intermarginal* plates. On the proximal third of ray usually every third plate bears a spine; beyond this about every fourth. Terminal plate small, with a semicircular series of about 5 small spines on the distal margin.

There are no papulae between the marginal plates, nor actinally. The larger papular areas (those on the median proximal region of ray) contain 3 to 5 papulae; the others 1 or 2.

The body is overlaid by a tough skin of medium thickness which covers everything but the sharp tips of the spines. It contains numerous glands which are rendered visible by a short immersion in caustic potash. The skin is crowded everywhere with minute perforated plates sometimes as many as 4 deep but usually about 2 deep. They are always so close that several overlap one another. They vary in form from dumbbell-shaped rods with 1 or 2 perforations to roundish or oblong, elliptical, smooth plates with from 4 to 8 perforations, the plates being predominant. The border of the plates is irregular, with short protuberances. The medium-sized plates measure about 0.04 mm., and the largest 0.05 mm., longest diameter.

Adambulacral plates with proximally 3 (distally 2 or 3) rather slender spines in a vertical series, the 2 lower standing one above the other on the furrow face of the plate, while the third is on the furrow margin proper, and the series is united along the whole length of the furrow by a continuous membrane, forming a serrated border to furrow and usually closing it by interlocking more or less with the spines of the opposite side. This spine is the longest of the 3, being about one and one-half times the width of plate, acicular, sharp. On account of the heavy membrane it appears stouter than it really is. The spine below this is a trifle smaller, while the lowest is compressed, curved at the base and shorter still. The three are united by membrane, at least basally. Some of the proximal plates have only 1 spine in the furrow, but usually there are 2.

Mouth plates with 2 spines on the margin of furrow, and on the furrow face of the plate 2 smaller spines, the upper usually but not always larger than the corresponding (middle) adambulacral spine. Just back of the mouth plates and between them and the inferomarginals (which extend proximad as far as the third adambulacral) is a fair-sized actinal intermediate plate bearing a spine similar to those of the inferomarginals. On either side of this, and wedged in between the third and fourth adambulacrals and first inferomarginals, are 2 or 3 very small, almost rudimentary actinal intermediate plates. These are, of course, invisible unless the integument is thoroughly cleaned off. There are thus 5 or 6 actinal intermediate plates entirely distinct from the rather numerous intermarginals which form a large part of the actinal area of disk.

Madreporic body small, raised, flat-topped, with few striations. It is situated a trifle less than one-half r from center.

Color in alcohol, bleached reddish brown.

Type.—Cat. 37001, U.S.N.M.

Type-locality.—Station 5483, Surigao Strait, off Cabugan Grande Island, 74 fathoms, sand, broken shells; 2 specimens.

Distribution.—Philippine Islands, 74 to 76 fathoms, on sand.

Specimens examined.—Three: 2 from type-locality and 1 from station 5140, off Jolo, Sulu Archipelago, 76 fathoms, fine coral sand.

Remarks.—This species bears a certain resemblance to *E. callosus*, but the disk is much larger, the ray shorter, and broadest at base, not slightly constricted as in *callosus;* the spines are much less prominent: the skin is thinner, especially around the spines; papulae fewer: skeleton more regular; there are usually 3 adambulacral spines in a vertical series (2 in *callosus*), and the deposits of the skin are very numerous, fairly evenly distributed, and in the form of perforated plates, rather than branched rods or rather open plates in streaks or areas. The plates are so numerous in the specimen from station 5140 that they form several layers in places and nearly always overlap. In *E. callosus*, which I examined, the deposits might be described as being scattered.

Echinaster acanthodes H. L. Clark (1916, p. 61) from Queensland is nearly related to the present species and greatly resembles it. *E. acanthodes* has, on every other adambulacral plate, except on the 12–16 plates nearest the mouth a conspicuous subambulacral spine, in addition to the three spines in the furrow. Deposits in the skin are not described.

Genus OTHILIA Gray.

Othilia Gray, 1840, p. 281.—Type, *Asterias spinosa* Retzius, 1805 (not Pennant, 1777) = *Asterias echinophora* Lamarck, first species (by designation, Fisher, 1913*b*).—Fisher, 1911*d*, p. 260; 1913*b*, p. 195.

Echinaster Müller and Troschel (part), 1840*a*, p. 102; 1840*b*, p. 321; 1842, p. 22.—Authors generally.—Verrill, 1914*a*, p. 206; 1915, p. 35.

Considerations which have led to the retention of *Othilia* as the name of this restricted group, instead of *Echinaster* Müller and Troschel, have been discussed under the preceding genus.

OTHILIA PURPUREA Gray.

Plate 122, fig. 1; plate 132, figs. 7, 7*a–b*.

Othilia purpurea Gray, 1840, p. 282.

Notes on Philippine specimens.—The specimens vary as to length of ray. One with long, slender rays has R=86 mm., r=12 mm., R=7 r; ray 7 times as long as its breadth at base, measured alongside from interbrachial angle. Another specimen with stouter, broader rays has R=81 mm., r=15 mm., R=5.4 r: longest ray 5 times its breadth at base. The rays are generally unequal in length.

Of the 24 specimens, 12 have 6 rays and 2 madreporic bodies, 4 have 5 rays and 2 madreporic bodies, 1 has 6 rays and 1 madreporite, 1 has 5 rays and 1 madreporic body, 3 are comet forms (6 rayed, and 1 has 2 madreporic bodies): 2 six-rayed and 1 five-rayed specimens each have the madreporic bodies (which are normally small) too inconspicuous to determine exactly.

The photographic figures will sufficiently show the external form of the species. It remains to note the arrangement of papulae and a few other features which are not very well known. Just external to the adambulacral plates and without intervening papular pores is a straight series of inferomarginal plates, about 10 corresponding to 16 adambulacrals. These plates are four-lobed and extend from behind the mouth plates, where there is an odd plate, to the tip of the ray. This is similar to the arrangement in *Henricia* except that the prominent actinal intermediate series is lacking. The odd plate just referred to probably corresponds to the odd actinal intermediate plate which I have found in *Echinaster callosus* and *E. stereosomus*, and is not a true inferomarginal. The superomarginal plates are immediately above, and separated by a series of papular areas, containing usually only a single papula (sometimes 2 or 3 at base of ray). Near the base of the ray (as in *Henricia*) the superomarginal series bends upward and reaches the interradial line about midway between mouth and anus. The angular space between the 2 series is filled in with intermarginal plates and about 6 or 7 papular areas.

The abactinal plates form roundish or more or less irregular meshes, 10 to 12 of which can be counted across ray from one superomarginal series to the other. These meshes are largest in the midradial region, and contain between 5 and 10 papulae. Most of the abactinal and all the marginal plates bear a short central, conical, blunt spinelet, heavily invested in membrane.

The skin contains crowded holothurianlike perforated plates having an irregularly elliptical, oval, or subcircular form with 10 to 20 perforations. Many are very irregular and in the form of branched and perforated rods. These are incomplete plates. The largest plates are about 0.05 mm. in diameter (see pl. 132, figs. 7, 7*a–b*). If a light-colored specimen is immersed for a short time in caustic potash the crowded deposits can be readily seen with a strong hand lens as a minute grayish granulation in the skin. These deposits are slightly thicker around the edges of the papular pores where they form rings. This immersion in caustic also reveals numerous glands scattered over the body, such as have been described for *Echinaster callosus* by v. Marenzeller and *E. sagenus* by Ludwig.

The adambulacral armature consists of 3 spines. Deep in furrow is a short, slightly curved, blunt, strongly compressed spine of a rather spatulate form but oriented with edge to furrow. The tip of this just about reaches the base of the second spine, which stands on the edge of the adambulacral plates and is stouter, longer, compressed, and truncate at the tip. This series is united by thick membrane, and forms a serrate border to the furrow, the spines of one side usually fitting into the intervals between the spines of the opposite side. The spines of the same series are separated by a space about equal to their own thickness. Just back of them is the third spine, the bases almost touching, but as the outer spine is directed away from the furrow it appears in the undried and uncleared specimen to be considerably spaced from the second. The adambulacral plates are small, wider than long, and separated by an interval about one-half their own length.

This species practises autotomy as shown by the comet forms, both of which have the buds of 5 new rays. In one specimen two tiny madreporites are visible.

Type-locality.—Mauritius.

Distribution.—Red Sea, Zanzibar, Mauritius, Mergui Archipelago, Madras, Philippines, Molucca Islands, Timor, Torres Strait, northeast Australia, New Zealand.

Specimens examined.—Twenty-four:

Specimens of Othilia purpurea examined.

Station.	Locality.	Depth, fathoms.	Nature of bottom.	Number.	No. of rays.	No. of madreporites.
5109	25.8 miles SW. Corregidor Light, Luzon	10	Coral	1	6	(?)
5158	Off Tinakta Island, Tawi Tawi Group, Sulu Archipelago.	12	Coarse sand, shells.	1	6	1(+?)
5159	do.	10	Coarse sand	1	6	(?)
5159	do.	10	do.	2	6	2
5159	do.	10	do.	1	5	(?)
5160	do.	12	Sand	2	6	2
5164	Off Observation Island, TawiTawi Group.	18	Green mud	2	5	2
5165	do.	9	Coral	1	5	1
5165	do.	9	do.	1	5	2
5165	do.	9	do.	1	6	1
5165	do.	9	do.	1	6	2
5218	Off Anima Sola Island, between Burias and Luzon.	20	Coarse sand	1	6	2
5248	Gulf of Davao, Mindanao	18	Coral	1	6	2
5249	do.	23	Coral, sand	2	6	2
5253	do.	28	Coral	2	6	2
	Cataingan Bay, Masbate	Seine, off beach.		1	6	2
	do.	do.		1	5	2
	Tataan Pass, Simaluc Islands, Tawi Tawi Group.	Shore		1	6	(?)
	San Miguel Harbor, Ticao Island between Masbate and Luzon.			1	6	2

Remarks.—Writers who have seen this species and the subsequently described *O. cridanella*—notably Müller and Troschel, Perrier, de Loriol, and Koehler—do not say wherein the two differ. The range of *cridanella* is coextensive with the eastern part of that of *purpurea*, while both forms have either 5 or 6 rays and 2 maderporic bodies. The authors referred to above have recorded the species as follows:

O. eridanella is recorded by Müller and Troschel from New Ireland (1842, p. 24); by Perrier (1875, p. 105) from New Caledonia; by de Loriol (1893, p. 391) from Amboina (also by Döderlein, 1896, p. 322); by Koehler (1910*a*, p. 174), who compared his specimens with the types, from Ganjam, India. *O purpurea* is recorded by Müller and Troschel (as *E. fallax*) from "India and the Red Sea" (1842, p. 24); by Perrier from the Philippines and the Red Sea (1875, p. 106); by de Loriol from Mauritius (1885, p. 10); by Koehler from the Aru Islands (1910*b*, p. 288).

I suspect that the two names refer to one variable species. Even if the specimens in the eastern part of the range differ sufficiently from those of Mauritius and westward, the former are not likely to be separable from Gray's previously described *Othilia luzonica* (1840, p. 282). De Loriol, an astute systematist, compared specimens of *purpurea* from Mauritius with six-rayed examples from the Philippines without finding any important differences. What differences do exist between *eridanella* and *purpurea*?

O. purpurea has been listed by Farquhar[1] (1898, p. 315) from New Zealand, and by R. N. Rudmose Brown (1910, p. 35) from the Mergui Archipelago.

Through the kindness of Dr. H. L. Clark, I have seen several specimens, both five- and six-rayed, collected by him in Torres Strait, at Thursday Island, and Emb (Murray Islands).

Genus HENRICIA Gray.

Henricia GRAY, 1840, p. 184. Type *H. oculata* Gray [*Asterias sanguinolenta* O. F. Müller].

With few exceptions the species of this genus are very variable and consequently difficult to identify accurately, even with specimens for comparison. Identifications based upon descriptions and figures are less reliable.

Although the three forms listed below have been given full specific rank, and are apparently very different, experience with *Henricia* in the North Pacific has taught me to go carefully, because wide difference in appearance is not a barrier to intergradation. However, in this case there is no alternative, because material is scanty. It will not be surprising if *Henricia arcystata* is a Philippine race of the Andaman *H. mutans*. As for *H. densispina*, the identification can only be made certain by a comparison with specimens from the type-locality. The type is certainly an immature form. I have no suggestions to offer as to the relationship of *H. microplax*. Its resemblance aborally to *H. sanguinolenta* is very superficial. I do not think its relations lie in that direction.

---

[1] On the Echinoderm Fauna of New Zealand. Proc. Linn. Soc. New South Wales, 1898, pt. 3, Aug. 31.

The student will find the figures a more reliable means of identification than the descriptions, which are susceptible of being misunderstood, or of being stretched to cover variations which they are not meant to include.

HENRICIA DENSISPINA (Sladen).

Plate 118, figs. 2, 3; plate 119, figs. 1–3.

Cribrella densispina Sladen, 1879, p. 432, pl. 8, figs. 5–9.

Diagnosis.—Rays 5, slender, either subcylindrical or depressed, tapering, rather long, but varying according to size; abactinal papular areas about same size, or larger than plates, sometimes including a secondary plate or two within the mesh; papulae usually 1 to 3; spinelets numerous, very delicate, ending in a sharp point or points; 3 regular series of plates adjacent to adambulacral plates, the median the larger; adambulacral plates with 2 or 3 compressed spinelets in vertical series in furrow and upward of 25 on surface. R=53 mm., r=7 mm., R=7.5 r; breadth of ray at base, 7 mm.

Description.—The meshes of the abactinal skeleton are smaller than in *H. arcystata*, with usually 1 to 3 papulae. Most of the meshes have no secondary plates and where these are present there are only 1 or 2. Although the trabeculae are narrow, as in *arcystata*, the spinelets are more numerous and fully twice as long, ending in several exceedingly delicate points. The abactinal surface has much the appearance of that of the less extreme specimens of *Henricia leviuscula multispina* Fisher, while *arcystata* would correspond to *H. l. annectens*, but with slenderer, generally smaller spinelets.

Parallel to the adambulacral series are 3 regular rows of plates, the inner extending two-thirds to three-fourths the length of the ray, the other 2, the marginals, reaching to the tip. The actinal intermediate and superomarginal plates are subequal, oblong to subcircular, with 30–35 spinelets. The inferomarginals are larger, subtriangular (the base distad and slightly excavated or concave) and correspond to the superomarginals in position and generally also to the intermediate plates, so that the three form a transverse series. A series of single papulae ocur intermarginally and inframarginally. Sometimes the inferomarginals have more the Y shape of those of *arcystata*, but in that case the spinelets are more numerous and longer.

Adambulacral plates with 2 or 3 small compressed spinelets forming a vertical series on the furrow face. Subambulacral spines 10 to 25 on proximal third of ray. An angular group of 6 to 8 conforms to the angular furrow margin of the plate, of which 5 usually stand on the projecting margin while the other spines rapidly diminish in length, the outer half of the plate being occupied by 15 to 20 small spinelets, which grade into those of the actinal intermediate plates. The longest spines next to furrow are equal to 1.5 adambulacral plates in length, and are shorter than in *arcystata.* The spines are webbed together by their bases, as also are those of the abactinal and marginal plates (but less conspicuously). In this form the adambulacral spines are very much more numerous than in *arcystata,* while the spines along the furrow margin are slightly shorter.

Madreporic body situated at about the middle of r, variable in size, usually rather small, with few ridges which are closely covered with spinelets.

Type-locality.—Straits of Korea (Sladen).

Distribution.—Straits of Korea; central part of Philippine Archipelago, 169 to 423 fathoms.

Specimens examined.—Eleven, from the following stations:

5510, Iligan Bay, north coast of Mindanao, 423 fathoms, gray mud, fine sand, bottom temperature 53° F.; 1 specimen.

5517, 10.5 miles northeast Point Tagolo Light, Mindanao, 169 fathoms, bottom temperature 54.3° F.; 1 specimen.

5519, near 5517, 182 fathoms, globigerina, sand, bottom temperature 54.3° F.; 5 specimens.

5523, 6.7 miles northeast Point Tagolo, depth and bottom unrecorded; 2 specimens.

5524, 17 miles northeast Point Tagolo, 360 fathoms, sand, bottom temperature 52.8° F.; 1 specimen.

5536, between Negros and Siquijor, 279 fathoms, green mud, bottom temperature 53.5° F.; 1 specimen.

Remarks.—From station 5523 is a small specimen having R, 23 mm., and r, 5 mm., hence almost exactly the size of the type of *densispina,* which, of course, is a young specimen. As a consequence the abactinal skeleton is much less open than in the specimens described above, and the spinelets are fewer. On the furrow face of the proximal adambulacrals are two spinelets.

HENRICIA MICROPLAX Fisher.

Plate 120, figs. 3, 5; plate 121, fig. 2; plate 132, fig. 3.

Henricia microplax FISHER, 1917*b*, p. 91.

Diagnosis.—Rays 5. R=45 mm., r=7 mm., R=6.4 r; breadth of ray at base, 8 mm. Rays slender, depressed, slightly swollen at base; disk small with an interradial sulcus near margin. General appearance of abactinal surface similar to that of *H. sanguinolenta;* superomarginal plates forming an inconspicuous series; inferomarginals in a regular conspicuous series; several series of actinal intermediate plates at base of ray; adambulacral spines about 15, besides 3 or 4 on the furrow face of plate.

Description.—The abactinal plates are much smaller and closer together than in *densispina*, the papular areas are smaller and have but one papula, and there are fewer, shorter, and slightly stouter spinelets, about 10 to 15 to each separate group and arranged in 2 or 3 series. These plates are frequently crescent-shaped and sometimes two groups will be merged into one, partly surrounding a papular area. In *densispina* there are actually much fewer plates, which are larger and have a variable number of crowded spinelets—usually 25 to 50.

Along the lateral face of the ray is a rather indistinct line of superomarginal plates, which are about twice as large as the adjacent intermarginal plates, 2 to 3 rows of which form a triangular area prolonged in a single series half the length of ray, beyond which point the superomarginals are adjacent to the inferomarginals. The latter are broader than long, perfectly distinct, 2 or 3 times larger than the superomarginals, and are separated from the adambulacrals for three-fourths the length of ray by a series of actinal intermediate plates; a second series extends nearly half the length, a third about one-sixth, while 4 or 5 plates of a fourth series are present close to the interradial line.

On the furrow face of the adambulacral plates is a vertical series, or sometimes a group of 3, occasionally 4, small spinelets. As a rule only the uppermost is visible when the furrow is closed naturally. Subambulacral spines about 15 or 16 on proximal half of ray. Three form a triangular group on the margin and are spatulate, sometimes grooved at the end and much larger than the others. There are usually 2 smaller spinelets behind these, while the remainder form 2 or 3 irregular series and are granuliform in appearance.

Madreporic body situated at about middle of r fairly large, but inconspicuous on account of the ridges being covered with spinelets; striae radiating.

Type.—Cat. No. 37006, U.S.N.M.

Type-locality.—Station 5518, Mindanao Sea, off Point Tagolo, Mindanao, 200 fathoms, gray mud, globigerina, bottom temperature 54° F.; 1 specimen.

Remarks.—This species was taken in the general locality at which *H. densispina* was collected. There is no way to decide whether it is a variety of *densispina*, or a distinct form, on account of lack of material. The differences in the spines and abactinal plates have already been pointed out. In *densispina* the superomarginals are much more conspicuous, and are in contact with the inferomarginals for the length of the ray, there being only a few intermarginals on the disk. There is but 1 series of actinal intermediate plates, while in *microplax* there are several at the base of ray. This causes the inferomarginals to be bent outward so that they reach the interradial line at the ambitus. The general facies of the two forms is different. Both, however, have 3 small spinelets in the furrow, and numerous subambulacral spines. In *densispina* the latter are more numerous, however, and the furrow margin forms a more prominent angle.

This species differs from *H. praestans* (Sladen) in lacking the large primary meshes of the abactinal skeleton (which resemble those of *H. mutans*) and in having more than 1 spinelet on the furrow face of the adambulacral. Superficially at least there is considerable similarity between the actinal surfaces of the 2 forms.

HENRICIA ARCYSTATA Fisher.

Plate 118, figs. 4, 5; plate 119, fig. 4; plate 120, fig. 2; plate 132, fig. 4.

Henricia arcystata FISHER, 1917*b*, p. 91.

Diagnosis.—Similar in general appearance to *H. mutans* (Koehler), but with shorter rays, 2 or 3 spinelets on the furrow face of the adambulacral plates (instead of apparently 1), and with a distinct series of Υ-shaped inferomarginals and crescentic superomarginals. R = 72 mm., r = 10 mm., R = 7.2 r; breadth of ray at base, 9 to 10 mm. Rays slender, depressed, curved at the end, tapering very slightly.

Description.—Rays slender, depressed, and of the general form of those of *H. mutans* (but shorter), and the primary meshes of the skeleton usually smaller on the disk and proximal fifth of ray as in that species. In a specimen from station 5536 the meshes are as large on the disk as on the rays. These large meshes are irregular and contain 1 to 5 or 6 smaller plates which are not so prominent as the others, and form a secondary network separating fairly conspicuous papulae, of which there are 1 to 5 or 6 in each primary area on the ray. The rather narrow skeletal pieces bear about 3 or 4 rows of delicate, sharp, very small spinelets.

Extending about four-fifths the length of ray adjacent to the adambulacral plates and corresponding to them is a series of intermediate plates, the elevated spine bearing tabulum being wider than long and covered with numerous sharp, short spinelets. The intervals between the plates are as wide as the length of the tabulum, rather deep and without papulae. External to these is a fairly regular series of three-lobed or Υ-shaped plates oriented with the arms transverse to the axis of ray. The vertical portion of the Υ (which is very short) is parallel to furrow and separates a couple of papulae, this double series continuing to the end of ray. Adjacent to these is a series of smaller, mostly crescentic, plates, oriented obliquely, representing the superomarginals. Both series of marginals have numerous tiny spinelets similar to those of the abactinal surface. At base of ray there are 1 or 2 extra short intermediate series of plates and 1 short intermarginal series, sometimes extending a third of the length of ray.

On the furrow face of the adambulacral plates, which are slightly wider than long, is a vertical series of 3 or 2 compressed spinelets. On the actinal surface are about 8 or 9 prominent spines of which 3 form, usually, a triangle on the furrow margin, 2 slightly shorter stand back of them, and 3 or 4 decidedly shorter, but much longer than the actinal intermediate spinelets form a group on the outer end of plate. The prominent spines are tapering, pointed, and about 2 plates in length. The subambulacral spines form a bristling armature along the borders of the furrow, notable by their superior length over all the other spines.

The madreporic body is slightly convex, small, and situated at about the middle of r. The striae are few, transverse, and bear tiny spinelets, usually in a single series on the top of the ridge.

Type.—Cat. No. 37067, U.S.N.M.

Type-locality.—Station 5536, between Negros and Siquijor, 279 fathoms, green mud, bottom temperature 53.5° F.; 3 specimens.

Distribution.—Central part of the Philippine group, 279 to 530 fathoms.

Specimens examined.—Four; besides the types, 1 from station 5219, between Marinduque and Luzon, 530 fathoms, green mud, bottom temperature 50.8° F. (typical).

Remarks.—This slender-rayed form differs from *H. mutans* Koehler in having well-defined marginal plates, and a vertical series of usually 3 spinelets on the furrow face of the adambulacral plate. The lowest of these 3 spinelets is close to the end of the ambulacral plate. I am uncertain whether *mutans* has more than the 1 furrow spinelet. In the description, the plates are said to have "3 spines on the inner edge directed into the furrow." The furrow spinelets of *arcystata* are in a distinct vertical series and not on the furrow margin as generally understood. In *mutans* the actinal plates are described and figured as being arranged without order. *H. mutans* was dredged near the Andaman Islands in 480 fathoms.

From *H. praestans* (Sladen), *arcystata* differs in having the 3 furrow spinelets, slenderer rays, less compactly placed actinal plates with larger actinal papular areas, and longer spines bordering the furrows. This species was taken off the Crozet Islands in 210 fathoms, and is a subantarctic form.

Family ACANTHASTERIDAE Fisher, 1911.

Genus ACANTHASTER Gervais.

Acanthaster Gervais Dict. sci. nat., suppl., vol. 1, 1841, p. 470. Type, *A. echinus* (=*A. planci* Linnaeus.)

ACANTHASTER PLANCI (Linnaeus).

Asterias planci Linnaeus, Syst. Nat., ed. 10, Appendix, 1758, p. 823. Quotes Columna, *Phytobasanos*, pl. 33, fig. A.—Verrill, 1914*a*, p. 364; 1914*b*. p. 16.
Asterias echinites Ellis and Solander, Nat. hist. zooph., 1786, pl. 60 to 62.
Acanthaster echinus Gervais, Dict. sci. nat., suppl., vol. 1, 1841, p. 474.
Acanthaster echinites Lütken, Vidensk. Medd., 1871, p. 292.
Acanthaster planci Verrill, 1914*a*, p. 373.

The largest specimen, from Pangasinan Island, has: R=185 mm., r=85 m., 6 madreporic bodies, and 15 rays. The abactinal spines of the disk are of medium length (10 to 15 mm.), those of the distal two-thirds of the ray being much stouter and longer (25 mm.). The spines have prominent pedicels or columns to which they are articulated, and the abactinal pedicellariae are long and slender. There are generally 3 furrow spines of conspicuous size, with a very short, stubby spinelet at either or both ends; or in place of the adoral spinelet, a short, obtuse, slightly tapered two-jawed pedicellaria. A majority of the plates have a prominent compressed, tapered, two-jawed pedicellaria, about three-fourths as long as the longest furrow spine, situated on the furrow face of the plate, near the adoral edge. It is usually oriented so that the jaws are dorsal and ventral. The subambulacral and actinal intermediate spines are prominent and grooved on the outer side of the distal half or third.

In the specimen from near Zamboanga, which is smaller than the last (R=130 mm.), the spines are all longer, the abactinal spines of disk being 20 to 25 mm. long and those near the end of the ray about 35 mm. There are 13 rays and 8 madreporic bodies. Furrow spines usually 3, sometimes 4. The prominent furrow pedicellaria is usually present. The subambulacral and actinal intermediate spines are slenderer and not so prominently grooved at the tip. The abactinal pedicellariae are long and slender (about 2.5 mm.).

In the specimen from Cataingan Bay (R=160 mm.) the abactinal spines are still longer, being about 25 to 35 mm. in length on disk and 45 mm. on ray; rays 13; madreporic bodies, 4; furrow spines usually 3, with an adoral, rather prominent, pedicellaria, and another in the furrow. The subambulacral and actinal intermediate spines are tapered and grooved for a short distance at the tip.

A relatively small example from Destacado Island (R=73 mm.) has long abactinal spines, 14 rays, and 5 madreporic bodies.

Type-locality.—Goa, Portugese India (Columna's figure).

Distribution.—Red Sea to the Philippine and Ryukyu Islands, Molucca Islands, Viti, Fiji, and Samoan Islands.

Specimens examined.—Four:

Pangasinan Island, vicinity of Jolo, coral reef; 1 specimen.

Little Santa Cruz Island, vicinity Zamboanga, reefs; 1 specimen.

Cataingan Bay, Masbate, coral reefs; 1 specimen.

Lode Bay, Destacado Island, between Samar and Masbate, rocks and coral; 1 specimen.

ACANTHASTER BREVISPINUS Fisher.

Plate 117; plate 118, fig. 1; plate 131, figs. 6, 6*a–d*.

Acanthaster brevispinus Fisher, 1917*b*, p. 92.

Diagnosis.—Resembling *A. mauritiensis* de Loriol, but differing in having the abactinal spines of disk reduced to mere spinelets, in having smooth or nearly smooth disk spines on both surfaces, and in having only 2 or 3 furrow spinelets, shorter than the length of their plate instead of decidedly longer. Rays 14 to 16. R=90 mm., r=51 mm.; R=1.76 r.

Description.—Abactinal surface of disk beset with numerous, slightly tapered, skin-covered spinelets, 2 mm. or less in length. They frequently end in a slightly expanded three-edged, pointed tip. Most of the spinelet is smooth, but a few granules are found around the base of the spinelet proper and sometimés for a third of its length. On some of the spinelets the granules, which are hidden by membrane until dried, mount up one side nearly to the expanded tip. The spines of the rays are more widely spaced and vary from 5 to 10 mm. in length. They increase in size toward the end of the ray and have a sparse fine granulation usually hidden by skin. In *A. planci* the spines are articulated to an elevated tabulum or column, but in this form the column is almost wanting.

The abactinal spines are more numerous and much closer together on the disk than in *A. planci*, as the abactinal skeleton has a closer mesh. Granulation of abactinal surface spaced and fine on disk, increasing in coarseness and density toward the margin. Abactinal pedicellariae small, two- or three-jawed, and 0.5 to 0.75 mm. high. The jaws are thick, round-tipped, and the whole pedicellaria may be nearly as broad as high. In *A. planci* the abactinal pedicellariae are very slender, the jaws being 3 to 6 times longer than the width.

Furrow spinelets 2 or 3, occasionally 1, short, unequal, tapered, the longest generally a little shorter than its plate. When there are 3 the median is the longest. In the furrow, abactinad to the adoral furrow spinelet is a prominent two-jawed pedicellaria and about the same length as an average furrow spine. Its jaws are oriented dorsal and ventral. The subambulacral spines are about as long as two plates, or a trifle less, slightly tapered, bluntly pointed, and sometimes faintly grooved on the outer side near the tip.

The actinal intermediate spines (of which the innermost series extends nearly to end of ray) are about two-thirds the length of the subambulacrals on the disk, and subequal on the ray. On the disk the intermediate spines are in about 3 irregular chevrons, including that adjacent to the subambulacrals. Inferomarginal spines, 17 or 18; superomarginal spines about 7, the longer 6 to 9 mm. in length. Actinal granulation rather coarse, though the skin magnifies the size of the actinal granules. This granulation is found also on the base of the spines, but not on the shaft.

Mouth plates narrow, with usually 5 stout flattened spines, followed by 3 short spinelets, just back of which is a prominent suboral spine.

Madreporic bodies, 3 to 5.

Type.—Cat. No. 37027, U.S.N.M.

Type-locality.—Station 5149, off Sirun Island, Sulu Archipelago, vicinity of Siasi, 10 fathoms, coral, shells; 2 specimens.

Remarks.—The differences between this form and *A. mauritiensis* and *A. planci* can be best appreciated if put in synoptical form.

- *a*¹. Adambulacral spines 3 to 5 ordinarily conspicuously longer than their own plate; spines at least of abactinal surface obviously granulated usually for nearly their whole length; abactinal pedicellariae with long, slender jaws.
  - *b*¹. Abactinal spines long, acicular, borne on high columns or pedicels belonging to the cruciform and rather widely spaced plates; spines of disk, including pedicels, one-third to one-fourth length of ray, measured along side; actinal spines with a fine granulation, or with a large part of the spine nearly smooth; subambulacral spine equal to about 3 adambulacral plates in length, occasionally 3.5 ---------- *A. planci.*
  - *b*². Abactinal spines distinctly short, those of disk (including pedicel) not exceeding, and usually not attaining, one-sixth the length of ray, measured along side; actinal spines with a course granulation covering greater part of spine, at least on one side; subambulacral spine less than 3 adambulacral plates in length ---------- *A. mauritiensis.*
- *a*². Adambulacral spines 2 or 3, occasionally 1, not longer than their plate; abactinal spines of disk usually smooth for most of their length, with a three-edged tip, and usually less than one-twelfth the length of ray measured along side; abactinal pedicellariae with short, thick jaws; actinal spines smooth for the greater part of their length; subambulacral spines equal to 2 adambulacral plates in length ---------- *A. brevispinus.*

As compared with *planci* the disk spinelets of *brevispinus* are much more numerous, owing to the closer meshed skeleton, and are insignificant in size.

A. ellisii Gray is not well known. It is described by Perrier as having the spines disposed very nearly as in *planci*, but completely devoid of granules. The pedicellariae are very short. The rays are either 19 or 15, madreporic bodies 7, and the adambulacral furrow spinelets are 2 or 3, nearly equal and divergent. Gray's original diagnosis (1840, p. 281, *Echinaster Ellisii*) states that the type, which is from South America, has 11 or 12 rays, *15 madreporic bodies* ("dorsal warts"), and large thick spines. In his generic diagnosis of *Echinaster* (=*Acanthaster*, s. s.) he states that the spines are very long and covered with *granular* skin, and have generally a second articulation about one-third the length from base. This would indicate that both his *E. ellisii* and *E. solaris* are large-spined species with high pedicels or tabula, and granules on the spines.

Family SOLASTERIDAE Perrier, emended.

Genus SOLASTER Forbes.

Solaster Forbes, Mem. Wernerian Nat. Hist. Soc., vol. 8, 1839, p. 120. Type, *Asterias endeca* Linnaeus.

SOLASTER TROPICUS Fisher.

Plate 125; plate 126, fig. 2; plate 133, figs. 2, 2*a*–*b*.

Solaster tropicus Fisher, 1913*c*, p. 221.

Diagnosis.—Rays 9 or 10; R=145 mm., r=53 mm., R=2.7+r; breadth of ray at base, about 35 mm. Disk large, rays fairly broad at base, tapering to a pointed extremity. Pseudopaxillae very small, well spaced, with 4 to 6 small spinelets; inferomarginal plates prominent, with numerous spinelets increasing very rapidly in size toward the inner or lower end of the compressed, transversely oriented tabulum or pedicel; distal marginals with mostly large spinelets only; furrow spines 5 or 6, rather long; subambulacral spines 5 to 7, subequal in length to furrow spines but heavier; the inner end of the transverse comb is turned aborad, and the innermost spine is shorter than the second; superomarginal paxillae small, alternating with the inferomarginals. Resembling somewhat *S. paxillatus*, but with more numerous furrow spines, less conspicuous subambulacrals, heavier inferomarginal spinelets, less conspicuous superomarginals, and fewer paxillar spinelets.

Description.—Abactinal surface covered with very small pseudopaxillae about 0.5 to 0.75 mm. in diameter and spaced 2 to 4 times their width. On the disk they bear 5 or 6 and on the ray about 4 small prickly spinelets, united into a fascicular group by membrane. The paxillae are about 0.5 to 0.6 mm. in height and are relatively more widely spaced on the rays than on disk. On the sides of the rays they are arranged in slightly oblique transverse series. Papulae prominent. In each interradius midway between center and margin there is a streak or area where the paxillae are sparse. Abactinal plates delicate, 4-lobed in the small specimen but in the type often three-lobed, or in the form of rods. The plates of the lateral portions of ray are united into transverse series independent of each other, or the lobes may touch, depending somewhat upon the amount of inflation of the integument. In the radial region, the plates are frequently independent, and small as well as medium-sized plates are present in the large incomplete meshes of the skeleton. These growing plates are oval, elliptical, or incipiently 3-lobed.

In the small specimen the inferomarginals define the ambitus, but in the type they retreat slightly onto the ventral surface in the interbrachium. Inferomarginals 48, compressed as in *S. paxillatus* with proximally a low fan-shaped pedicel, the width of which diminishes distad. Proximally, the spiniferous margin is about twice the height and bears about 30 spinelets, small at the outer end and increasing in length toward the inner, where 5 or 6 spinelets are 6 or 8 times the length of the outermost, sharp, and invested in pulpy membrane. On the outer part of the ray the pedicels become narrower and the larger spinelets occupy the greater part of the free margin, the small spinelets becoming greatly reduced in number, usually to a few at the upper or outer end. As compared with *paxillatus* the inner spinelets of the inferomarginals are decidedly larger and are more as they are in *S. borealis*, but the spinelets are more numerous and the pedicels lower. In *borealis* the lateral spines are very conspicuous on the distal marginals.

Superomarginals very small, with 8 or 10 spinelets, and situated usually above an interspace between 2 inferomarginals.

Actinal interradial areas large, containing 6 chevrons of plates (4 in small specimen), bearing each 5 to 8 pointed spines, heavily invested in membrane. These fascicles of spines are well spaced (usually about the length of the spines apart). Two series of intermediate plates extend to the eighth inferomarginal and a single series (each plate with usually only 1 spine) extends nearly to the tip of ray.

Furrow spines, 5 or 6, the median slightly the longest, all united by web for two-thirds their length, the membrane often forming a spatulate pad at the tip of each spine. The spines are tapering, pointed, and rather long, being 1⅓ to 1½ the length of base line of comb, and long enough when erect to extend well above surface of plate. Subambulacral spines usually 5 to 7, tapering, pointed, basally webbed and heavily invested in membrane, about equal in length to the furrow spines, but much heavier. The inner spine is shorter than the other 4 or 5 and situated aborad of the transverse line made by the series; or 2 spines form a longitudinal series just back of the furrow series, and 3 or 4 others a transverse series across plate opposite the interspace between first 2 spines. The subambulacrals are joined by a slight web to the furrow fan.

Marginal mouth spines, 11 or 12, the inner 3 of each plate pointed, long, the innermost as long as the base line of entire series; the outer 8 or 9 much slenderer and shorter and decreasing in length toward the outer end of margin. All are united by membrane. Suboral spines about 10 (6 in small specimen), in an irregular series parallel to median suture. In the type they are smaller than the marginal spines, but in the small specimen the inner 1 or 2 are about as long as the fourth or fifth marginal spines. Along the median suture margin is a row of low papillae without a calcareous core.

Madreporic body, 4 mm. in diameter, prominent, surrounded by about 6 pseudopaxillae, and situated its own diameter adcentral to the middle of r.

Type.—Cat. No. 32647, U.S.N.M.

Type-locality.—Station 5654, Gulf of Boni, Celebes, 805 fathoms; bottom not recorded, bottom temperature 38.3° F.

Distribution.—Known only from Gulf of Boni and Molucca Passage.

Specimens examined.—The type and a specimen from station 5619, off March Island, Molucca Passage, 435 fathoms, fine gray sand and mud.

Remarks.—This species is allied to *S. paxillatus* Sladen, but probably not very closely, while it also shows some resemblance to *S. borealis* Fisher, though it is not related to this form, unless remotely. The following differences separate *tropicus* from *paxillatus*: In *tropicus* the paxillae have fewer, relatively coarser spinelets; marginal plates lower, with conspicuously heavier spinelets at the inner or lower end than at the upper or outer, and distal marginals occupied almost entirely by a relatively few large spinelets (somewhat as in *S. borealis*); in *S. paxillatus* the inner marginal spinelets are only a little larger than the outer, and the armature of the distal marginals does not differ materially from that of the proximal; in *tropicus* the superomarginals are lower and less conspicuous, the furrow spines more numerous (5 or 6 instead of 3 or 4) and in large specimens the subambulacral spines are decidedly less prominent (subequal to furrow spines). *Tropicus* differs from *borealis* in having less prominent marginal plates and much more numerous and smaller marginal spines, distinguishable superomarginal plates, more numerous and longer furrow spines and more numerous and longer subambulacral spines. *S. torulatus* Sladen from north of the Kermadec Islands has less prominent marginals actinally situated, and with subequal spinelets; the furrow spines are shorter, the subambulacral spines fewer and in a straight series; the actinal interradial areas smaller, and the abactinal paxillar spinelets slightly more numerous. *S. regularis* Sladen has larger and more widely spaced paxillae, more prominent marginal plates, and the subambulacral spines form a straight series. *S. subarcuatus* Sladen has fewer inferomarginal spines (10–12), fewer furrow spines (3 or 4), and fewer oral and suboral spines. The species is said to resemble *S. endeca*, which *S. tropicus* does not.

Genus CROSSASTER Müller and Troschel.

Crossaster Müller and Troschel, 1840*a*, p. 103. Type, *Asterias papposa* Linnaeus.

The two genera, *Solaster* and *Crossaster*, have been united by most recent writers,[1] although in practice it is not very difficult to recognize them. Since new species of the *Crossaster* type are continually being described, it is becoming more and more desirable to keep them separate. A good differential character is the presence in *Crossaster* of a complete membraneous interbrachial septum between the internal interradial calcareous dorsoventral pillar and the margin. The pillar arises from the mouth plates and passes upward, its point of union with the abactinal skeleton being usually marked by a smooth spineless area. In *Crossaster papposus* between this calcified buttress and the margin there is a definite septum separating the gonads of adjacent rays, while in *Solaster endeca*, *S. borealis*, and *S. abyssorum* the pillar is present, but not the membranous septum; as a result the gonads of adjacent rays are not separated, and the coelom is continuous.[2]

CROSSASTER SCOTOPHILUS (Fisher).

Plate 124, fig. 1; plate 133, figs. 3, 3*a*.

Solaster scotophilus Fisher, 1913*c*, p. 222.

Diagnosis.—Related to *Crossaster papposus*, but differing in being of a much more delicate habit, with more numerous furrow and suboral spines, smaller paxillae, smaller and more numerous marginal paxillae, and a much more delicate skeleton. Rays 9; R=48 mm., r=14 mm., R=3.4 r; breadth of ray at base 10 mm.; disk large, rays slender, flexible, tapering to a sharp point; skeleton delicate, open, irregular; paxillae small, the pedicel about 0.5 mm. high and the longest spinelets 1.25 mm. long; marginal paxillae 24 or 25, delicate; furrow spines very delicate, 8 or 9; subambulacral spines 7 to 9; marginal mouth spines, 15.

Description.—Abactinal skeleton very open with widely spaced pseudopaxillae consisting of a low pedicel and ordinarily 15 to 25 very slender and sharp glassy spinelets, short about the periphery of tabulum and increasing in length to the center where they are 3 or

---

[1] For some of the reasons for uniting them see Fisher, 1911*d*, p. 389. Professor Verrill, 1914*a*, p. 259, recognizes *Crossaster* and remarks that "the dorsal ossicles do not form definite, oblique, transverse rows on the sides of the rays as they do in *Solaster*."

[2] Fisher, 1916*a*, p. 5.

4 times the length of the pedicel. There are 2 to 5 or 6 prominent papulae to each mesh. The primary plates have 4 slender lobes, which are connected to neighboring plates by upward of 4 or 5 elliptical overlapping ossicles, forming slender trabeculae. The meshes are not symmetrical and often several are confluent, especially on outer part of ray.

Marginal plates 24 or 25 prominent, with compressed pedicel bearing 50 or more very delicate spines which are decidedly longer at the lower end of the pedicel than at the upper, being 1⅓ to 1½ times the width of the pedicel. The marginal spines are also shorter than the central, as in the case of the abactinal plates. Between 2 marginal plates are 1 to 3 small abactinal paxillae. The marginals define the ambitus on the ray, but at the base pass to the actinal surface, keeping close to the adambulacral plates in consequence of the small size of the actinal intermediate areas.

Furrow spines very slender, 10 on the first plate, then 9, then 8 or 9, and on the outer part of the ray, 6. The median spines are longest and about 1½ to 2 times as long as the base line of comb, while the lateralmost are commonly only one-half as long as the base line, the intermediates being graduated in length between the two. They are united for about one-third their length by membrane. On the surface of the plate is an oblique, arcuate, transverse comb of 7 to 9, usually 8 or 9, slender, basally webbed spines, the inner 5 or 6 subequal and about 1⅓ to 1½ the length of the median furrow spines, but slightly stouter, the outer 2 or 3 considerably and progressively shorter. The spines are borne on an elongate slightly crescentic tumidity of the plate, the inner end of which is at the aboral furrow corner of the plate and the outer near the outer adoral corner. When the spines are spread fanwise with the points adorad (instead of being bent aborad and obliquely away from furrow) the base of the comb is nearly a semicircle and the special ridge has the appearance of a low pedicel comparable to the marginal pedicels but much less conspicuous.

Mouth plates with 15 slender, marginal spines united basally by a web, and increasing in length from the outer toward the inner end of the plate, the innermost spine being as long as the base line of the marginal series. Suboral spines about 13, in a zigzag series the length of plate, basally webbed, and when standing erect forming a rather dense group on the companion plates, the ends of the spines rising well above the marginals (except the innermost to which the suborals are nearly equal). The spines, when separated, seem to form 3 oblique transverse series from the median suture aborad toward the margin.

Madreporic body situated a little nearer margin than middle of r, and with a large paxilla on the adcentral side.

Type.—Cat. No. 32648, U.S.N.M.

Type-locality.—Station 5651, Gulf of Boni, Celebes, 700 fathoms, green mud, bottom temperature 38.7° F.; 1 specimen.

Distribution.—Known only from type-locality.

Remarks.—The only species, besides *Crossaster papposus*, to which *C. scotophilus* shows close resemblance, are *C. penicillatus* Sladen, from off Marion Island, 140 fathoms, and *C. japonicus* (Fisher) from the Sea of Japan. *C. japonicus* is of the habit of *C. papposus*, having large penicillate paxillae, and heavier spines generally than occur in *scotophilus*. From *penicillatus*, *scotophilus* differs in having much more numerous furrow spines (4 or 5 in *penicillatus*), more numerous marginal paxillae, and smaller and more delicate abactinal paxillae.

Genus LOPHASTER Verrill.

Lophaster VERRILL, Amer. Journ. Sci., ser. 3, vol. 16, 1878, p. 214. Type, *Solaster furcifer* Düben and Koren.

LOPHASTER SULUENSIS.

Plate 123, fig. 2; plate 124, fig. 3; plate 132, figs. 8, 8*a*.

Lophaster suluensis FISHER, 1913*c*, p. 219.

Diagnosis.—Resembling *L. furcilliger* Fisher in general form but with much lower paxillae, especially marginal, the pedicels being much shorter than the spines; inner or lower inferomarginal spines conspicuously longer than upper; furrow spines 5 or 6, rather long; subambulacral spines 3 or 4, heavier and longer than furrow spines, and equal to about 2 plates in length. Rays 5; R = 82 mm., r = 16 mm., R = 5 r; breadth of ray at base, 19 or 20 mm.; rays slender, gradually tapering, bluntly pointed; abactinal surface arched; actinal surface plane.

Description.—Abactinal plates strongly 4-lobed, with a low pedicel, bearing 7 to 10 tapering, thorny, pointed spines, the median slightly longer than the peripheral. The spines vary from 1 to 2 mm. in length, while the pedicel is ordinarily about one-half the length of the spines, slightly wider than high on the rays and slightly higher than wide on central portion of disk. Papular areas of apical region with 5 to 7 papulae; those of proximal part of ray with 3 or 4 papulae; those of distal portion of ray with 1 or 2. Counting across the base of ray there are about 18 longitudinal series of plates, rather irregular in the median radial region.

Marginal paxillae comparatively small, the superomarginal decidedly smaller than the inferomarginal and usually alternating with them. The inferomarginal paxillae have low pedicels, about as high as broad, surmounted by about 15 to 18 spines of which 3 or 4 on the side toward furrow are about 2.5 mm. long, while the others decrease in size to about 0.75 mm. on the dorsal side of the paxilla. The proximal superomarginals have 12 to 15 spines and the pedicel is about two-thirds the height of the inferomarginal pedicels, while the tuft of spines is of about half the bulk of the inferomarginal spines. Actinal interradial areas small, the plates bearing 3 or 4 spinelets and extending in a single series about two-thirds the length of ray.

Furrow spines 5 or 6, usually 6, slender, tapering, webbed for two-thirds their length, the 4 median the longest, and about 1½ times the length of base line of comb. Consecutive combs are separated by an interval equal to one-half to the entire length of the base line comb. Subambulacral spines 3 or 4, tapering, pointed, the outermost commonly the longest, or the 2 or 3 outermost subequal and about twice as long as the median furrow spines, as well as much stouter, the end of the spines being sometimes a trifle swollen. They are united by web at the base only.

Marginal mouth spines 12 or 13, webbed, and increasing in length toward the innermost. Suboral spines, 2 to 4 on the median suture margin near outer end of plate.

Madreporic body prominent, situated at about the middle of r.

Type.—Cat. No. 32646, U.S.N.M.

Type-locality.—Station 5423, Sulu Sea, off Cagayan Island, 508 fathoms, gray mud, coral sand; bottom temperature 49.8° F.; 1 specimen.

Remarks.—This species is characterized, so far as the single specimen allows one to judge, by the very low pedicels and relatively long spines. The marginal paxillae are small, but the subambulacral spines are unusually large. *L. suluensis* differs from *L. furcifer* in having longer, slenderer rays, longer paxillar spines, and relatively shorter pedicels, longer and unequal marginal paxillar spines, more numerous furrow spines, and very much longer subambulacral spines, the latter being longer than the marginal paxillae with their spines. The mouth plates of *L. suluensis* are larger, with more numerous and longer marginal spines (12 or 13). *L. suluensis* differs from *L. stellans* Sladen, and *L. abbreviatus* Koehler (Antarctic species) in having a much less robust form, longer rays, more numerous furrow spines (4 short ones in *stellans* and 3 rather long ones in *abbreviatus*) and much more prominent subambulacral spines (longer, not shorter, than marginal paxillae with their spines). *L. suluensis* resembles, in general form, more nearly 2 Antarctic species: *L. antarcticus* Koehler and *L. gaini* Koehler, but differs in having 5 or 6 instead of 4 furrow spines, and 12 or 13 instead of 7 or 8 marginal mouth spines. *L. antarcticus* has 20 to 40 paxillar spines and much less prominent subambulacral spines when compared either with the fairly long furrow spines or the more prominent inferomarginal paxillae. *L. gaini* has more prominent paxillar pedicels, less thorny paxillar spines, more prominent inferomarginal paxillae, and the actinal intermediate paxillae are reduced to about 4 in each interradial area. In *L. suluensis* they extend at least two-thirds the length of the ray.

Genus XENORIAS Fisher.

Xenorias (subgenus) Fisher, 1913*c*, p. 222. Type, *Rhipidaster* (*Xenorias*) *polyctenius* Fisher.

Diagnosis.—Differing from *Rhipidaster* Sladen in the position of the marginal plates which are oblique, but instead of being parallel with one another are inclined at an angle of 45° and touch by the intermarginal ends, forming a series of chevrons along the side of ray. Abactinal plates and adambulacral plates essentially as in *Rhipidaster.*

XENORIAS POLYCTENIUS (Fisher).

Plate 120, fig. 1; plate 123, fig. 1; plate 133, figs. 1, 1*a–b*.

Rhipidaster (*Xenorias*) *polyctenius* Fisher, 1913*c*, p. 222.

Diagnosis.—Rays 7; R=50 mm., r=14 mm., R=3.5+r; breadth of ray at base, 12 mm.; rays slightly convex, tapering evenly to bluntly pointed extremity. Differing from *Rhipidaster vannipes* in having very much shorter abactinal spinelets invested in a common sheath; curiously compressed, obliquely oriented, lateral superomarginal and inferomarginal plates (with intermarginal ends adorad) bearing a transverse comb of webbed spines, those at the aboral end of each plate much larger than the others; furrow spines 9 or 10; subambulacral comb of 4; abactinal integument pulpy, hiding the skeleton which consists of 3 or 4 lobed closely imbricated plates; papulae 1 to 3 to each mesh.

Description.—Abactinal surface covered with rather uniformly distributed fascicular tufts of small spinlets invested in a common pulpy sheath from which the tips of the spinlets protrude a short distance. These fascicles with their investment are about 1 mm. long and 0.75 mm. in diameter, and resemble tubercular projections of the integument. In those which appear to be nearly normal the investment forms a collar surrounding the spinelets which are themselves embedded in the central pulpy part of the sheath. These fascicles are spaced about once their own diameter, or less, on disk and base of rays, and are arranged in quincunx on the sides of the rays. Each pseudopaxilla consists of a low pedicel or convex plate, surmounted by 8 to 12, or sometimes fewer very delicate tapering glassy spinelets closely bound for their basal half by tissue, and ending in several very sharp glassy points. On the central part of disk and outer part of ray many plates have 5 or 6 spinelets. The abactinal integument between the fascicles of spinelets is thrown into numerous irregular wrinkles.

On the midradial region the abactinal plates have usually 3 truncate lobes and on the lateral region 4, by which they overlap strongly, the small meshes containing 1, 2, or rarely 3, papulæ.

The marginal plates are conspicuous, low, transverse ridges oriented obliquely and bent aborad, so that each pair of marginals appears to form a chevron, the angle of which is toward base of ray, for the reason that the lower end of each superomarginal touches the upper end of the corresponding inferomarginal. A long series of chevrons thus occupies the side of each ray. Superomarginals 40. The spine-bearing crest has the appearance of being bent aborad and the upper end is in the form of a slight knob which bears 3 prominent, tapering, sharp, closely appressed spines (the median usually the longer), which, relative to the width of plate, are more prominent distally; 6 to 9 much slenderer, shorter spinelets continue this series to the lower end of the plate, and at the same time become shorter; these spines are united by a web.

The inferomarginal plates are formed and armed just like the superomarginals, except that the long spines (3 or 4 in number) are at the lower or actinal end and are longer than the corresponding superomarginal spines, being slightly longer than the extreme width of plate. Three to 5 small spines continue this series toward the intermarginal line. The large inferomarginal spines are on the angle between the lateral and actinal faces of the ray, and proximally a fourth spine is added to the actinal end of the series. The points of the spines frequently converge (the median being longest) and the group has then the appearance of Sladen's figure of the "actinal intermediate" spines of *R. rannipes*. The inferomarginal series of *N. polyctenius* evidently corresponds to the series of plates described by Sladen as actinal intermediates. When the marginals are cleaned they are seen to be imbricated in their own series, the adoral end slightly overlapping the aboral end of the next plate toward the mouth. The plates are curiously formed and slightly bent, the outer end of each suggesting the end of a femur flattened or the dorsal end of a rib. The intermarginal end is narrower as if the bone had been cut off at that point.

Actinal intermediate plates about 3 only, just back of the mouth plates, and bearing a very few spinelets.

Furrow spines 9 or 10, distally 8, united by membrane for two-thirds their length into a prominent scoop-shaped fan very much as in *R. rannipes*. The central 3 or 4 are longest, and are equal in length to about 1⅓ the base line of the comb. On the surface of the plate is an oblique comb of 4 stouter, tapering, sharp spines, the 2 median the longest and slightly longer than the furrow spines. The subambulacral comb resembles the inferomarginal comb, and the armature of the adambulacrals closely resembles that of *R. vannipes*, except that the furrow spines are slightly more numerous. The actinal surface of the adambulacral plates is short and wide, the outer end underlying the ventral swollen end of an inferomarginal, to which the adambulacrals correspond in number. The surface midway between the outer and inner ends bears an oblique tumidity for the reception of the subambulacral comb. The inner end of the plate broadens fan-wise for the reception of the furrow comb. The sutures between consecutive plates are actinally 2½ to 3 times the actinal length of the plate at its most constricted part.

Mouth plates prominent and strongly convex at the outer end. Marginal spines 15 to 17, the 3 inner long, slender, pointed, and directed over actinostome, the remainder usually standing upright and much shorter and slenderer. They are united for about two-thirds their length by a web which is continuous between the series of companion plates. Near the inner end of the plate stands a slender, sharp, prominent, suboral spine adjacent to median suture and near its companion of the other plate; 3 shorter spines stand on the convexity near the outer end of plate midway between suture and furrow margins.

Madreporic body medium-sized, with 3 plates close to margin, and situated at about the middle of r.

Type.—Cat. No. 32649, U.S.N.M.

Type-locality.—Station 5622, off Makyan Island, Molucca Islands, 275 fathoms, gray mud; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—*Xenorias* is more comparable to *Rhipidaster* than to any other known genus, and the most important difference has been indicated in the generic diagnosis. It may be well to mention other differences, which are not necessarily generic. The abactinal skeleton of *X. polyctenius* has small meshes, with generally only 1 papula to a mesh, while *R. vannipes* has a wide-meshed, reticulated skeleton, with upward of 5, 6, or even more papulae to a mesh. In the latter the plates bear a penicillate tuft of 4 or 5 prominent, sharp spinelets, apparently free from thick membrane, while in *polyctenius* the spinelets are very small and are immersed in a common sheath.

The marginal plates of *Xenorias* are peculiar in their orientation. They are situated on the side of the ray and are oriented at an angle of about 45° to its long axis, in such a way (pl. 133, fig. 1*a*) that the inferomarginal forms a chevron with the superomarginal, pointing toward base of ray. The free end of each plate is larger than that meeting its fellow at the intermarginal line and bears the largest spines.

Family MYXASTERIDAE Perrier.

Genus MYXASTER Perrier.

Myxaster PERRIER, Comptes Rendus, vol. 101, 1885, p. 886. Type, *M. sol* Perrier.

MYXASTER MEDUSA (Fisher).

Plate 134, figs. 2, 2*a–c*.

Asthenactis medusa FISHER, 1913*c*, p. 224.

Diagnosis.—Rays 9. R=225 mm., r=52 mm., R=4.3 r; breadth of ray at base, 25 mm. Rays very flexible, slightly swollen at base, tapering, elevated, and somewhat trigonal in section; integument yielding, the plates very thin, and the skin soft and slimy; spinelets about 6 to a fascicle, the fascicles membrane invested and close-set; adambulacral spines webbed, 9 or 10, the outermost belonging to the next, adoral, plate; mouth spines, 13 or 14, webbed. Differing from *Myxaster sol* in having more numerous and longer mouth spines, a thicker skin, and 2 instead of 3 spines on the apophysis of each adambulacral plate.

Description.—Abactinal plates very thin, imbricated, each bearing a fascicle of extremely delicate spines, usually about 6, although sometimes slightly more numerous, and resembling fine glassy hairs. The abactinal surface is covered with soft membrane, which forms an investment to the spines. The fascicles are 6 to 8 mm. long and spaced 2 or 3 mm. apart. The form of the plates is variable; some are four-lobed, others hourglass shaped. The figures will give a better idea of the form. Owing to the softness of the integument and the overlying slime I have not been able to discover any papulae on the outside, but an examination of the coelomic surface of a portion of the dorsal body wall shows single papulae in the interspaces between the lobes of the plates.

Adambulacral armature similar to that of *Asthenactis papyraceus* (but lacking, of course, the actinolateral membrane). Each curved oblique comb consists of 9 or 10 very delicate spines, webbed to their tips and increasing in length from the inner to the outermost, the last spine standing on an extension of the next adorally situated plate. The innermost spine is one-fourth to one-third the length of the outermost, and the latter is joined to the side of the ray by a flange-like extension of the web, about as broad at base as one-third the length of outer spine. This flange of tissue narrows rapidly in width up to the tip of the spine, and near the outer edge envelops a tiny fascicle of 2 or 3 setalike spinelets of a lateral plate. These are hidden by the membrane.

Mouth plates large, with a straight median suture, the form and armature being shown by the figure. The marginal spines form an angular series, the first to sixth or seventh being on the actinostomial margin, the seventh or eighth on the angle of the plate at mouth of ambulacral furrow, and sometimes directed across mouth of latter, while the remaining 5 or 6 form a fascicle or group on the surface of the plate adjacent to the very short *furrow* margin and to the first adambulacral comb. All the spines are joined by membrane, the innermost being nearly as long as median suture; the others decrease in length to the spine at the angle of plate, which is one-half the length of the median suture, while the longest of the remaining 5 or 6 spines is slightly longer, the others nearly as long.

Madreporic body slightly convex, 6 mm. in diameter, and situated slightly adcentral to the middle of r. The actinostome is wide (38 mm.) and the tube feet large, with large sucking disks. Gonads large, in a compact mass at base of ray. Apparently there are 2 ducts, one opening near ambitus and another about one-third r from margin, on the interradial line. The eggs are large, 1 to 2 mm. in diameter. A membranous interbrachial septum is present. It extends about one-third r from margin toward center of disk, and not so far as the inward extension of the gonads.

Type.—Cat. No. 32650, U.S.N.M.

Type-locality.—Station 5605, Gulf of Tomini, Celebes (lat. 0° 21′ 32″ N.; long. 121° 34′ 10″ E.), 647 fathoms, bottom not recorded.

Remarks.—In the original description, I suggested that this species might really belong in *Myxaster*, if the type of that genus should be found to possess the same peculiarity in respect to the disposition of the adambulacral spines. On account of the structure of the adambulacral plates, I placed *medusa* in *Asthenactis*, in which each adambulacral fan is divided between 2 plates, the outer spines of each series standing on an oblique aboral extension or apophysis of the next adorally situated plate. No mention of this highly characteristic arrangement of plates and spines was made by Perrier in his description of *Myxaster sol.* In June, 1914, I examined the type of this species at the Museum d'Historie Naturelle of Paris. In *Myxaster sol* the adambulacral plates are constructed essentially as in *M. medusa*, 3 spines, as a rule standing on the apophysis, while 5 or 6 continue the series on the body of the next aboral plate.

It becomes evident, therefore, that the structure of the adambulacral plates and the peculiar arrangement of spines are the same in both *Asthenactis* and *Myxaster*, and that the presence of an actinolateral membrane is the one trenchant character which separates *Asthenactis* from *Myxaster.*

Myxaster medusa differs from *M. sol* in having a much thicker skin, which completely hides the underlying plates; the mouth plates are broader, with a broader actinostomial margin and a decided angle to the plate at mouth of ambulacral furrow; the mouth spines are 13 or 14 instead of 8, and the outer spines form a fascicle on the surface of the plate near the margin, instead of a series, without a web, on the margin. The apophysis of the adambulacral plate, in *medusa*, has 1 long spine; in *sol*, 3. There seems to be a difference in the form of the plates of the abactinal and lateral surfaces of the body, but it is not possible to determine how constant this is.

The family Myxasteridae includes only 3 genera, *Myxaster*, *Asthenactis*, and *Pythonaster*.[1]

Family PTERASTERIDAE Perrier.

Genus PTERASTER Müller and Troschel.

Pteraster Müller and Troschel, 1842, p. 128. Type, *P. militaris* (O. F. Müller).

PTERASTER CORYNETES Fisher.

Plate 127, figs. 2, 3; plate 128, fig. 1; plate 133, figs, 5, 5*a*.

Pteraster corynetes Fisher, 1916*b*, p. 28.

Diagnosis.—Abactinal surface resembling superficially that of *P. pulvillus;* probably more nearly related to *P. semireticulatus*. Paxillae with low pedicel surmounted by 7 or 8 longer, radiating, peripheral spinelets surrounding a central shorter one; tips of peripheral spinelets united by fibrous tissue; spiracula in lines between spinelets; no deposits in supradorsal membrane; furrow fans with 7 spines (distally, 6); actinolateral spines stout, the tips defining ambitus; 5 oral spines, the 10 united by a continuous membrane; suboral spine may be entirely lacking; when present, slender, tapering. Rays 5; R=24 mm., r=13 mm., R=1.8 r; breadth of ray of base, 14 or 15 mm.; thickness of disk, 9 mm.

Description.—Abactinal surface resembling somewhat that of *P. pulvillus* and also that of *P. semireticulatus*. Supradorsal membrane very thin, so that the 7 or 8 widely radiating peripheral spinelets of each paxilla can be easily seen, a much shorter erect spinelet occupying the center of each circle. The paxillae, in consequence, have a stellate appearance, and a peripheral fibrous band connects the tips of all the spinelets (except the central), marking off the abactinal surface into areas, somewhat as in *semireticulatus*, but these bands are not at all conspicuous, except on the sides and outer half of ray. Between any 2 radiating spines is a linear series of 4 to 7 spiracula, usually quite small. Pedicel of paxillae short and stout on the rays, being about half the length of the peripheral spinelets, which are also stout, and tapered from the truncate, minutely denticulate lip toward the base. They resemble little clubs with spiny tips, whence "*corynetes*." On the largest paxillae, at base of ray, the peripheral spinelets are a trifle short of 2 mm. long, while the central, clavate, truncate in form, is about 1.5 mm. long. There are no deposits in the supradorsal membrane. Osculum small, closed, the special spines forming a low protuberance.

---

[1] Verrill, 1914*a*, p. 204, has made a special family of *Pythonaster*, but without diagnosis. I do not know in what particulars, therefore, it differs from the Myxasteridae.

Adambulacral combs with 7 spines, the inner end of each series, comprising the first 3 spines, bent obliquely downward and aborad. The inner spinelet is very short, one-half to two-thirds as long as the second; the second, two-thirds the length of the third; the next 4 increasing slightly in length, the outermost being generally the longest, although the difference in the length of the outer 3 is not great. Membrane between the spines, which are sharp, slightly emarginate. Aperture and papilla small, the papilla broad, and round-tipped. Distal combs with 6 spines.

Mouth plates with 5 marginal spines, increasing rapidly in length from the outer, which is short, toward the innermost, which is half again as long as the median suture. All 10 spines of each mouth pair united by a continuous membrane. Three pairs of plates are entirely without suboral spines; one pair has a spine on 1 plate, while the fifth mouth angle has a suboral spine on each plate. This spine is nearly as long as the inner marginal spine, and is slender, tapering, with a sharp hyaline tip.

Actinolateral membrane broad, the margin defining ambitus, but not forming a conspicuous fringe. The tips of most of the actinolateral spines can be seen from above. Actinolateral spines stout, the tip slightly flaring as a rule and truncate; sixth spine reaching margin of membrane. The first 5 spines meet or cross the tips of their fellows of adjacent ray along the interradial line. Owing to proportions of r to R, the actinal interradial areas are not very board, although the entire actinal floor outside the adambulacral fans is occupied by the actinolateral membrane. At the sixth actinolateral spine, half the distance from furrow margin to ambitus is occupied by the adambulacral fans; at middle of ray, measured along side, a little more than half.

Type.—Cat. No. 37014, U.S.N.M.

Type-locality.—Station 5623, Molucca Passage, 7.5 miles northeast Makyan Island (lat. 0° 16′ 30″ N.; long. 127° 30′ E.), 272 fathoms, fine sand, mud; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—In my key to the species of Pteraster (1911*d*, p. 368) *Pt. corynetes* belongs to the second section, although the rays are slightly longer than in the other species. Among those species having all the oral spines united by a continuous membrane, only 5 are comparable with *corynetes*, namely *pulvillus*, *temnochiton*, *rugatus*, *semireticulatus*, and *ingolfi*, to none of which it is closely related. The following synopsis will contrast the characters:

- a^1. Adambulacral combs with 5 to 7 spines.
  - b^1. Suboral spine, when present, slender; aperture slits small; no deposits in supradorsal membrane.
    - c^1. Paxillae with high pedicel and 5 to 15 spines; R=1.3 r; actinolateral membrane narrow, not defining ambitus; suboral spines always present .... *pulvillus.*
    - c^2. Paxillae with low pedicel and about 8 spines; R=1.8 r; actinolateral membrane defining ambitus; suboral spines absent from some plates. *corynetes.*
  - b^2. Suboral spine with 3 sharp edges; aperture slits unusually large; minute branched rods in supradorsal membrane .... *temnochiton.*
- a^2. Adambulacral combs with 3 to 5 spines.
  - b^1. Adambulacral spines usually 3, sometimes 4, short, scarcely projecting beyond web; R=1.4+r .... *rugatus.*
  - b^2. Adambulacral spines 3 to 5, usually 4, projecting far beyond web.
    - c^1. R=1.75 r±; dorsal membrane thin, evidently reticulated. *semireticulatus.*
    - c^2. R=1.4 r±; dorsal membrane thick, not at all reticulate .... *ingolfi.*

Three species are said to lack the suboral spine entirely: *personatus*, *sordidus*, and *reductus*. It is not possible to determine whether the three suboral spines in the single specimen of *corynetes* are abnormally present. The species differs, however, from *personatus* and *sordidus* in having more numerous adambulacral spines, and from *reductus* in having only five oral and fewer paxillar spines. *P. sordidus* has a straight series of adambulacral spines, the inner 4 of the 6 oral spines are webbed independently, and the actinolateral membrane interradially extends beyond the true margin of the ray. All three forms are from the east Atlantic.

PTERASTER OBESUS MYONOTUS Fisher.

Plate 127, fig. 1; plate 128, fig. 3; plate 133, fig. 4.

Pteraster obesus myonotus Fisher, 1916*b*, p. 28.

Diagnosis.—Closely related to *P. obesus* Clark of Japan and resembling superficially *P. pulvillus* Sars. Differing from *obesus* in being nearly pentagonal in form; in having a fairly tough supradorsal membrane in which there are well-developed bands of muscle forming a reticulum of hexagons and triangles, and in having fewer paxillar spines. R=28 mm., r=24 mm., R=1.2 r; height of disk 18 or 19 mm.

Description.—The general form is nearly pentagonal, there being only slight interradial indentations, and the disk is thick and cushionlike. Supradorsal membrane fairly thick and bristling uniformly and thickly with the tips of the paxillar spines which raise the membrane or project about 1.5 to 2 mm. above the general level.

The apexes of these projections (there being usually three spine-tips to each) are connected by strong muscle bands so as to outline more or less regular hexagonal spiracular areas, in the center of which a single spine (the central one of a paxilla) projects, and this is connected by radiating muscle bands, somewhat weaker than the others, with the 6 peripheral projections outlining the area. Six, more or less evident, triangular subareas are thus formed. Each hexagonal area contains 50 to 60 small spiracles. The spiracular areas and bristling spines extend to and occupy large actinal interradial areas, as the actinolateral fringe is narrow. Osculum of conspicuous size surrounded by a fringe or web forming a truncated cone 3.5 mm. high and about 7 in diameter at base; aperture slightly stellate. Pseudopaxillae with tall pedicels (4 mm. on radial areas) and with usually 7 (sometimes 1 or 2 more) slender, webbed spinelets, subequal to or a little shorter than the pedicels, which have 4 short lobes at the base. No calcareous bodies in supradorsal membrane.

Adambulacral spines 5 (6 on first few plates), the innermost very short and the succeeding spines increasingly longer, all united by a web, which extends to tip of spines but is rather deeply emarginate between. Aperture about a third as long as outermost spine. The latter is connected by a web to the actinolateral membrane, which is narrow as in *obesus* and of nearly uniform width except near the extremity of ray, its spines being subequal in length and one-third to one-half again as long as the outermost adambulacral spine. Tube feet in 2 series; furrow rather narrow, about two-thirds width of actinolateral membrane.

Mouth plates with the innermost of the 7 or 8 free oral spines flattened and truncate, and one-fourth to one-fifth as broad as long. The next is three-fourths as long, much slenderer, slightly tapered, and flattened. The next 3 or 4 are about three-fifths as long as the second and quite slender. Two similar spinelets are placed above the outer 2 marginal spinelets, really on the edge of the actinal face of the plate, making a group of 4 at the mouth of the furrow. Suboral spine sharp, much more robust than inner oral spine and one-fifth longer. The distal half is hyaline, tapering, three-edged.

Young.—A specimen from station 5483 has been referred, not without some hesitation, to this species. Its dimensions are: R=13 mm., r=9.5 mm. The rays are more apparent than in larger examples, and on either side of the tip of each is a conspicuous brown spot. The supradorsal membrane is tough and the muscle bands of the adult are well developed, though the projections are much more irregularly distributed than in the type and the hexagonal areas are not apparent. The spiracles are less numerous but are conspicuous, the rim of each being brown. The mouth plates have 6 or 7 oral spines, the innermost being relatively a little slenderer than in the adult, but the small outer spinelets are placed on 2 slightly different levels as described in the type. Most of the adambulacral plates have 5 spines joined by a transparent web. This specimen can be readily separated from *P. obesus* on the character of the reticulated, fairly thick, supradorsal membrane.

Type.—Cat. No. 37015, U.S.N.M.

Type-locality.—Station 5518, Mindanao Sea, off Point Tagolo, 200 fathoms, gray mud, globigerina; bottom temperature 54° F.; 1 specimen.

Distribution.—Mindanao and Surigao Seas, and vicinity Philippine Islands, 74 to 279 fathoms, mud.

Specimens examined.—In addition to the type, 7 from the following stations:

Station 5483, Surigao Strait, east of Leyte, 74 fathoms, sand, broken shells; 1 specimen.

Station 5523, 6.7 miles northeast Point Tagolo Light, Mindanao Sea; 1 specimen.

Station 5536, between Negros and Siquijor, 279 fathoms, green mud, bottom temperature 53.3° F.

Remarks.—I have given this form the status of a subspecies because it is obviously very close to *obesus* and is separated from it by what may be termed minor characters. In other words it seems to be a "small species." *Pteraster obesus* is known only from a single specimen from Sagami Bay, Japan. In my key to the species of *Pteraster* (Asteroidea of the North Pacific, pt. 1, p. 368) the present race would be placed next to *obesus* under c^2 with the following differential characters:

f. No supradorsal reticulations; paxillar spines 8 to 10 or more; R=1.4 r. *obesus.*

f^2. Well developed supradorsal reticulations; paxillar spines usually 7 (or less than 10); R=1.2 r________ *myonotus.*

The disposition of the outer, small, oral spinelets of *myonotus*, which appears to be constant, may be a further difference.

The "key," referred to above, will show by the position assigned to *myonotus*, the principal characters by which the new form differs from others species of *Pteraster*.

Genus RETASTER Perrier.

Retaster PERRIER, Nouv. Archiv., 1878, p. 56. Type, *Pteraster capensis* Gray.

RETASTER INSIGNIS Sladen.

Retaster insignis SLADEN, 1882, p. 200; 1889, p. 482, pl. 76, figs. 3 and 4; pl. 77, figs. 11 and 12.

In the largest specimen from station 5253 R=74 mm. and r about 36 or 37 mm. The specimen agrees fairly well with Sladen's description of *R. insignis*. There are 3 or 4 spinelets to each pseudopaxilla, the longest about 3 times the length of the pedicel. The long spinelets, which push up the supradorsal membrane and form protuberances, are in groups of 4 (sometimes 2 or 3, and in a few cases, near the osculum, 5). Each spinelet of a group belongs to a different pseudopaxilla, so that ordinarily 4 pseudopaxillae contribute a spine to each protuberance, the center of the rhomboidal spiracular areas (marked by the center of the cross mentioned by Sladen) being directly above a pedicel. The pedicel which springs from a strongly cruciform base is 2 mm. high, and an average spinelet 6.5 or 7 mm. long. In the radial region of the disk each of the 4 triangular areas, into which the rhomboidal spiracular areas are subdivided, contains 18 to 30 pores which in the alcoholic specimen have very dark brown rims. The actinolateral spines and their web form a vertical palisade about 8 mm. high near the mouth plates. The first few adambulacral plates have 6 spines to each comb, the rest 5. The mouth plates have 8 or 9 marginal spines, webbed to the tip, and the innermost is commonly slightly shorter than the second and is usually connected, not with its fellow of the adjacent plate, but with the suboral spine of its own plate, the web extending halfway to tip of latter. This suboral spine stands back of the 2 inner marginal spines and is 7 mm. long. In Sladen's type of *R. insignis* the suboral spine is not connected with the marginal. The first adambulacral combs of adjacent rays (commonly with 7 spines) are webbed together over the outer end of the prominent mouth plates.

I have examined a specimen of *R. cribrosus* (M. C. Z. No. 963), a species with which *insignis* has been lately merged. It seems to me that the two are perfectly distinct. In true *cribrosus* the cross mentioned by Sladen as characterizing the spiracular areas is absent and the much fewer pores (about 35) are pretty evenly distributed—not segregated into triangular subareas. At the nodal points of the meshes of the supradorsal membrane 2 spines project, sometimes 1 or 3. There are only 3 furrow spines; 1 (not 3) stands on the furrow margin, while the other 2 form a transverse series with the actinolateral spine.

Type.—In British Museum.

Type-locality.—Arafura Sea, 25 fathoms.

Distribution.—Philippine Islands; Amboina; Banda Sea; Arafura Sea; Torres Straits; Thursday Island; Port Jackson and Port Molle, Australia; Samoa.

Specimens examined.—Four, from the following stations:

Station 5144, vicinity of Jolo, 19 fathoms, coral sand; 1 specimen.

Station 5252, Gulf of Davao, Mindanao, 1.5 miles southwest Linao Point, 28 fathoms, coral; 1 specimen.

Station 5253, same locality, depth, and bottom; 1 specimen.

Station 5356, North Balabac Strait, Palawan, 58 fathoms, sand, shells; 1 specimen.

Genus DIPLOPTERASTER Verrill.

Diplopteraster Verrill, Amer. Journ. Sci., vol. 20, 1880, p. 400.—Fisher, 1911, p. 370. Type, *Pteraster multipes* Sars.

DIPLOPTERASTER MULTIPES PATAGIATUS Fisher.

Plate 130, fig. 2.

Diplopteraster multipes patagiatus Fisher, 1916*b*, p. 28.

Diagnosis.—Closely resembling *D. multipes*, but differing in having narrower paxillar areas (exclusive of actinolateral membrane) and in having the same number of spines in both sorts of furrow combs (or if an unequal number, then one more in the nonprominent combs instead of one less, as in *multipes*); adambulacral spines longer. R=95 mm.; r=60 mm. (measured to edge of actinolateral membrane); R=1.5 r; r=50 mm., measured to edge of paxillar area; breadth of paxillar area at interradius, 50 to 57 mm. In *patagiatus* breadth of paxillar area at interradius=60 per cent or less of R; in *multipes* it equals 80 per cent, or more, of R.

Description.—The dorsal surface closely resembles that of *multipes*. The pseudopaxillae have pedicels slightly longer than the 2 central spines and decidedly longer than the 7 to 9 peripheral spines. There are usually about 7 spiracular areas radiating from the prominent central spines of a paxilla, with 6 to 9 spiracles to each (thus fewer than in similar large examples of *multipes;* see Fisher 1911*d*, p. 371). The actinolateral membrane forms a fleshy border to the entire ray, projecting beyond the paxillar area, so that in life the contour of the specimen was probably nearly pentagonal. Paxillar areas, broadly petaloid, convex, sharply differentiated from the patagial membrane.

Adambulacral spines slightly longer than in *multipes*. This is very apparent upon comparison of specimens but is a little difficult to describe. In *multipes* the longest spine of a comb equals the length of 4 adambulacral plates, measured along the edge of furrow; in *patagiatus* the longest spine equals 5 to 5.75 plates, in each case starting with the adoral margin of the plate upon which the spine has been measured, and omitting the fleshy flap of tissue at the tip of spine. The number of spines along the ray, beginning with the first plate, runs as follows, a star marking nonprominent plates: 6, 6*, 6, 6*, 6, 6*, 5, 5*, 6, 6*, 5, 6*, 5, 6*, 5, 5*, etc. In the nonprominent combs the first or inner 2 spines are ordinarily short, the innermost the shortest, while the next 4 are abruptly longer and subequal or increasing slightly in length toward the outermost, which equals as stated above, 5 to 5.75 adambulacral plates measured along edge of furrow (rarely 6). When there are 6 spines to a prominent plate the innermost is usually abruptly much shorter than the other 5, which are subequal or increase slightly in length toward the outermost. The spines of both kinds of combs are normally webbed beyond their tips, each spine being prolonged by a fleshy sacculus; but in most cases this is destroyed.

Mouth plates with 6 or 5 oral spines, united by a web to the tips, and the 2 series united by membrane. Inner oral spine 10 mm. long, while the length of the straight suture between the mouth plates, to outer beaklike projection is 7.5 mm. Suboral spine slenderer than inner oral spine and 8 mm. long.

Madreporic body large, convex, 10 mm. in diameter by 7 mm. high. There is a stout pedicel arising from the outer side near the edge, while in *multipes* the pedicel is at the edge. In some species of *Retaster* and *Pteraster* this paxilla arises from the summit (see Fisher, 1911*d*, p. 370, footnote).

Type.—Cat. No. 37016, U.S.N.M.

Type-locality.—Station 5656, Gulf of Boni, Celebes (lat. 3° 17′ 40″ S.; long. 120° 36′ 45″ E.), 484 fathoms, gray mud, bottom temperature 41.2° F.

Distribution.—Known only from type-locality.

Remarks.—*D. verrucosus* (Sladen) differs in having 15 paxillar spines and short adambulacral spines—much shorter than in *multipes*, while in *D. peregrinator* (Sladen) the central paxillar spines do not protrude beyond the rest, and the supradorsal membrane is not conspicuously spiny. The former species was dredged from the Atlantic entrance to the Strait of Magellan, while the latter was taken off Cumberland Bay, Kerguelen Island.

This race or small species is a long way geographically from its nearest known relative. *D. multipes*, differing in some particulars from typical Atlantic specimens, has been taken in Suruga Gulf, Japan, 475 fathoms, bottom temperature 39.1° F. (see Fisher, 1911*d*, p. 372).

Genus HYMENASTER Wyville-Thomson.

Hymenaster Wyville-Thomson, Depths of the Sea, 1873, p. 120. Type, *H. pellucidus* Thomson.

HYMENASTER RHODOPEPLUS Fisher.

Plate 129; plate 130, fig. 1; plate 133, fig. 6.

Hymenaster rhodopeplus Fisher, 1916*b*, p. 29.

Diagnosis.—Closely resembling *H. nobilis* Sladen but differing in having 7 instead of 6 rows of paxillae to each ray, in having a stouter and longer adambulacral spine (much longer than aperture papilla), and in having 2 acicular suboral spines to each plate (instead of 1 resembling an aperture papilla). Marginal contour pentagonal; R=82 mm., r=55 mm.; breadth of paxillar area at base, 35 mm.; distance from center of disk to margin of paxillar area on interradial line, 30 to 32 mm.

Description.—General appearance of abactinal surface very similar to that of *H. nobilis*, the paxillar areas being raised above the level of the very fleshy lateral membrane, and paxillae usually with 3 spines oriented as in *nobilis*. But there are 7 series of paxillae, instead of 6, to each ray, and in proportion to the 2 lateral, or outer, series of each side, the radial and either adradial are smaller than in *nobilis*. In *rhodopeplus* the paxillae of the 3 median series are abruptly smaller than the marginal paxillae, while in *nobilis* the paxillae are nearly uniform in size so far as outward appearance is concerned; at least there is no sharp break. Pedicel of superomarginal paxillae near base of ray 3 mm. long, spines 7 mm.; pedicel of radial paxilla, 1.75 mm., longest spine 6 mm., shortest 3.5 mm. The 3 spines are usually unequal on the radial and adradial paxillae, sometimes but much less often also on the marginal. Supradorsal membrane rather thin, but thicker between the spines of a paxilla than between the paxillae. Spiracula in lines around the paxillae but never among the spines of a paxilla, these lines meandering and joining to form an irregular meshwork. Extending laterally upon the interradial membrane from margin of paxillar area are about 15 to 20 linear spiracular tracts, such as occur in *nobilis*, the longest, the fifth or sixth, at about the middle of R, being one-half or two-thirds the width of the paxillar area. Some of these linear areas are branched once. Oscular orifice large, the bases of the oscular valves being raised above the general level of the paxillar area. The spines of the valves are about 1.5 times the length of the outer spines of the same paxilla; the membrane between the 2 sets of spines with a moderate number of paxillae.

Adambulacral armature consisting of a single (but on first plate, 2) slender tapering sharp spine (the point of which is frequently broken), normally much longer than the calcareous portion of the aperture papilla, and sometimes exceeding twice its length. A sacculus is present, but mutilated, owing to injury of the specimens in the net. The aperture papilla is broadly ovate to obovate, usually asymmetrical, and relatively large. Tube feet large, in 2 rows; purple, with a small light-brown sucking disk.

Armature of mouth plates consisting of 3 or 4 slender, tapering, sharp marginal spines, the series directed across mouth of furrow and spaced from the inner end of plate. These spines are very similar to the adambulacral spines and are either subequal or the spines at either end of the series are the longest. Two stout, tapering, sharp, suboral spines, much longer and stouter than the marginal, stand close to the median suture, the inner fairly on the actinostomial margin; the outer is slightly the longer and about as long as the straight median suture of the mouth plates, or sometimes only three-fourths as long.

Actinolateral membrane fleshy, thick, obscuring the very delicate actinolateral spines, which increase in length and nearly meet in the interradial line, up to the eleventh or twelfth spines, which are the longest. From here on the tips of the spines of adjacent rays become more and more separated, although the next 10 are nearly subequal in length. Near the end of the ray the spines project slightly at the edge of the actinolateral membrane.

Color in alcohol, bright pink, lighter on paxillar areas.

Type.—Cat. No. 37017, U.S.N.M.

Type-locality.—Station 5606, Gulf of Tomini, Celebes (lat. 0° 16′ 28″ N.; long. 121° 33′ 30″ E.), 834 fathoms, green mud; 2 specimens.

Distribution.—Known only from the type-locality.

Remarks.—The principal characters upon which this species is founded have been indicated in the diagnosis. Although *rhodopeplus* bears a very striking resemblance to *nobilis*, the differences are very important, especially in the number of rows of paxillae. *H. koehleri*, from Bering Sea, is a close relative of *nobilis*, but, like the latter, differs from *rhodopeplus* in having only 6 series of paxillae, which are nearer equal in size than in *rhodopeplus*.

This species has a thick, fleshy, actinolateral membrane and very weak spines, while in *H. bartschi* the membrane is relatively thin and the spines much stouter.

HYMENASTER BARTSCHI Fisher.

Plate 124, fig. 2; plate 133, fig. 7.

Hymenaster bartschi FISHER, 1916*b*, p. 29.

Diagnosis.—Very similar to *H. pullatus*, but differing in having the paxillar areas of the 5 rays separated interradially nearly to the oscular valves and in having numerous spiracula in the supradorsal membrane, there being a series of bandlike spiracular areas along either side of the paxillar areas extending toward the interradial line. General contour originally probably nearly pentagonal, produced at the corners into attenuate tips. R=about 70 mm. It is not possible to measure r accurately, as the lateral membrane is distorted and in some cases torn. Breadth of paxillar area, 22 to 26 mm.

Description.—The five paxillar areas petaloid, broadly lanceolate, distinct, separated one from another to within a short distance of the oscular valves; interradial spaces broad near margin, narrowing at the middle of r to about 3 to 5 mm., this narrow area separating the prominent paxillar spines of adjacent areas to within 5 mm. of the oscular valves. This narrow area is abundantly supplied with small spiracles to a point a little short of the middle of R, where begin a series of irregular, bandlike, dark-brown spiracular areas extending upon the grayish lateral membrane from the margin of the paxillar area, these forming a series, of which the fourth, fifth, and sixth from the inner end are the longest and extend nearly or quite to the interradial line. They are 12 to 15 mm. long, according to tension of actinolateral membrane. The lateral membrane adjacent to the paxillar area is colored brown. Supradorsal membrane very thin and transparent between the numerous conspicuous criss-crossing muscle bands, the interspaces provided with from 1 to 6 conspicuous spiracula. Pseudopaxillae in 7 rows along each ray. The outermost row consists of paxillae of conspicuous size, with pedicel 3 mm. long and 4 (sometimes 3) slender unequal spinelets, the longest 8 mm., the shortest 3 mm. The next row (toward the median line) consists of very much smaller paxillae, with pedicel about 0.5 mm. high, or less, and about 3 spinelets (or less) 2.5 mm. high. These paxillae are in a transverse line with the outermost. The paxillae of the next row alternate with these and with the median radial. Both the median and adradial are rudimentary, with 1 to 3 sessile spinelets from 0.5 to 1.5 mm. long, so that the supradorsal membrane rests upon the ambulacral ridge. The paxillae have 4 long, slender lobes, forming in the delicate dorsal integument a calcareous network with irregular meshes along the lateral regions and irregular rhomboidal meshes along the median area. The supradorsal membrane is raised at numerous points by the paxillar spinelets, from which the very definite branching muscle-bands radiate. Osculum prominent, the valves with 8 or 10 spines; about 4 spines belonging to the same paxilla radiate toward the end of the ray, the membrane between their tips and the base of the valves having numerous spiracula. The width of the real ray, omitting the supradorsal membrane, is only about 10 mm. at the base.

Ambulacral furrows narrow; tube feet large in 2 series. Furrow spinelets 3, flattened at the base and tapering to a point, the adoral slightly the longest (1.5 to 1.75 mm.). Each spinelet is capped by a narrow sacculus of variable length, but usually short. Aperture papilla very broadly obovate, about as long as the longest furrow spinelet. The calcareous part is slightly shorter than the longest spinelet as the papilla is bordered by a flange of tissue.

Armature of mouth plates very similar to that of *pullatus;* 4 marginal spines (the innermost not always spaced from the other 3) and

2 suboral in a series parallel to median suture. The inner suboral stands on the margin of plate close to the inner marginal spine, but is much thicker than the latter, and in turn is a little less robust. though longer, than the outer suboral. The mouth plates have all been more or less rubbed and injured.

Actinolateral membrane broad, rather thin, deep brown in color. Where this colored layer has been rubbed off a gray, finely fibrous layer is revealed. The longest actinolateral spines are the twelfth to seventeenth or eighteenth, which are about subequal and 13 or 14 mm. long.

Type.—Cat. No. 37018, U.S.N.M.

Type-locality.—Station 5428, Sulu Sea, off eastern Palawan (lat. 9° 13′ N.; long. 118° 51′ 15″ E.), 1,105 fathoms, green mud, bottom temperature 49.7° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—The description of *H. pullatus*[1] does not state the number of series of pseudopaxillae to each ray, nor whether those of the radial regions are so reduced in size as to be considered rudimentary. Neither the figures nor description indicate the presence of spiracula which are so plentiful in *bartschi.* The lateral areas of small spiracula, marked by a brown pigment against a grayish ground, are very conspicuous in the Philippine form, and probably not present in *pullatus.* In *bartschi* the adambulacral spines are more attenuate at the tips than in *pullatus*, while the aperture papilla is slightly broader. In proportion to the size of the aperture papilla and the base lines of the furrow comb, the actinolateral spines of *bartschi* are decidedly smaller at the base than are those of *pullatus.*

Hymenaster bartschi seems to be a representative species occupying the deep basin of the Sulu Sea. Whether it is to be regarded as a distinct species or only as a geographic race of *H. pullatus* will depend upon the value assigned to the absence of *spiracula* in *pullatus.* The characters of the paxillae are very positive in *bartschi*, and upon certain important points information in regard to *pullatus* is lacking. *H. pullatus* was dredged by the *Challenger* at station 218 off the north coast of New Guinea, southwest of the Admiralty Islands, in 1,070 fathoms, blue mud.

This species is named for Dr. Paul Bartsch, of the United States National Museum, who was naturalist during the Philippine cruise of the *Albatross.*

Genus HYMENASTERIDES Fisher.

Hymenasterides Fisher, 1911*a*, p. 425.

Diagnosis.—In general structure similar to *Hymenaster* but with two kinds of adambulacral plates alternating: (1) prominent plates bearing a transverse series of 3 rather long, slender spines, and (2) nonprominent plates with only 1 spine. Tube feet in 4 series, the feet of the outermost series corresponding to the nonprominent plates. Combined mouth plates produced actinally into a cone, the apex of which is about the middle of median suture. Two suboral spines.

---

[1] Sladen, 1889, p. 519.

HYMENASTERIDES ZENOGNATHUS Fisher.

Plate 127, figs. 4, 5; plate 128, fig. 2; plate 134, fig. 1.

Hymenasterides zenognathus Fisher, 1911*a*, p. 425.

Diagnosis.—Paxillar area raised above the actinolateral membrane which forms an even narrow border; paxillae in 9 longitudinal series, 5, or laterally, as many as 7 spines to a paxilla, one being longer than the rest; no visible muscle-fibers; scattered spiracula. Prominent adambulacrals with 3 slender membrane invested sacculate spines; nonprominent with one, each of which is opposite a tube foot of outer series. Mouth plates conical actinally with 2 suborals, and 3 or 4 marginals. Fourteenth actinolateral spine the longest. R=36 mm., r=22 mm., R=1.64 r. Breadth of ray, over all, 21 to 25 mm.; of paxillar area alone, 17 to 21 mm.

Description.—The paxillar area is sharply defined from the lateral fringe, or actinolateral membrane, which is interradially deeply indented and follows the contour of the raised supradorsal membrane. Thus the actinolateral membrane forms a narrow border of nearly uniform width, and the spines do not project beyond the edge. They are clearly visible, as the membrane is translucent. The supradorsal membrane is thin and translucent, without visible muscle-fibers, and with small, rather widely spaced, inconspicuous spiracula, which are not in definite areas but sometimes form irregular lines. With the exception of an interradial area they are pretty uniformly distributed all over the membrane. Membrane everywhere rough with the points of the paxillar spinelets, of which there are usually 5 (laterally sometimes 7) to a paxilla. The latter are in 9 quincuncial longitudinal series. Each paxilla springs from a cruciform or four-lobed base, the lobes overlapping those of 4 other plates leaving quadrate or lozenge-shaped papular areas. The pedicels are longest on the lateral paxillae; those of midradial series about half as long as the laterals, and the spines, which are webbed, are in all cases longer than the pedicels. One spine is usually longer and stouter than the others. The spines are three-edged or triradiate in cross section. The papulae (1 to an area) are attached to the pedicels. The valves guarding the osculum have a truncate summit and are strengthened by about 12 spines, of which the 5 or 6 median are longest. About 8 other spines, much shorter, form a comb just back of the valves, and are attached to the same pedicel. The membrane at the base of the fans is pierced by scattered spiracula, and that between the fans has numerous spiracula in short irregular lines. The supradorsal membrane is dotted with numerous very small whitish spots of unequal size, due probably to groups of gland cells. There are rather large, well-spaced, brownish rings or spots on the outer half of R.

Ambulacral furrow wide; tube feet, with small disks, in 4 longitudinal series. Adambulacral plates of two sorts, prominent and nonprominent. The former project farther into furrow and bear an oblique transverse series of 3 or 4 slender spines invested in membrane which forms a small sacculus at tip. The outer spine is the longest (equals the length of 5 plates at base of furrow), the other two decreasing slightly in length. The innermost often projects between 2 feet of the outermost series and is deeper in the furrow than the outer. The nonprominent plate corresponds to a tube foot of the outermost series, is set back slightly, and bears only 1 spine, which stands in the same longitudinal series (with reference to long axis of ray) with the outermost spine of the prominent plates, and is of about the same length as this spine. Aperture papillae short, broadly ovate, with a membranous envelope produced into a short, blunt sacculus. The calcareous part is only about one-fourth the length of the adjacent subambulacral spine, and there is no difference between the papillae of the two sorts of plates. The apertures are narrow and not completely covered by the papillae. The first adambulacral plate, sometimes prominent, sometimes nonprominent, has 2 equal or unequal spines and a large aperture papilla immersed in the actinolateral membrane.

Mouth plates small and very high, the combined pair produced actinally into a conical eminence, the apex of which is situated at the middle of the median suture. The height of this extraordinary beak or cone equals the interradial diameter of the pair of plates. From the blunt point at the top the plates slope straight and steeply to the actinostomial margin, which is produced into a slight beak, but in the opposite direction the plates diverge, leaving an open suture, and the margin of the plates is arcuate and nearly perpendicular. Marginal spines 3 or 4 (sometimes only 2), the lateral-most usually the strongest and longest, situated on a slight angle of the margin and directed across mouth of furrow. The innermost spine which is well spaced from the median beak of actinostomial margin is nearly as long as the lateral-most and the 1 or 2 intermediate spines are somewhat shorter. Suborals 2, nearly like the subambulacrals and situated in a line parallel to and near median suture, on the actinostomial face of the cone.

Actinolateral membrane translucent forming a broad margin which decreases in width evenly from interradial angle. The fourteenth spine is the longest, and is the first to meet the free edge of membrane. The first is articulated to the second adambulacral. The spines do not meet interradially their fellows of adjacent ray, but leave a narrow wedge-shaped area. The length of this wedge (the apex touching mouth plates) is about half the extent of the free edge of one ray measured along edge of actinolateral membrane. This actinolateral membrance is nearly flat.

Madreporic body globular, and without a paxilla on its surface.

Type.—Cat. No. 28660, U.S.N.M.

Type-locality.—Station 5623, Molucca Passage between Gillolo and Makyan Islands (lat. 0° 16′ 30″ N.; long. 127° 30′ E.), 272 fathoms, fine sand, mud; 25 specimens.

Distribution.—Sulu Archipelago, and Molucca Passage, 258 to 272 fathoms, mud and fine sand.

Specimens examined.—Eight, 4 from type-locality and 4 from the following stations:

Station 5549, vicinity of Jolo Island, Sulu Archipelago, 263 fathoms, sand, globigerina, foraminifera, bottom temperature, 52.3° F.; 1 specimen.

Station 5550, same locality, 258 fathoms, fine sand, shells, 52.3° F.; 2 specimens.

Station 5622, Molucca Passage, near Makyan Island (lat. 0° 19′ 20″ N.; long. 127° 28′ 30″ E.), 275 fathoms, gray mud; 1 specimen.

Remarks.—This genus constitutes a very distinct, new type, which differs from *Hymenaster* in much the same way that *Diplopteraster* differs from *Pteraster.* The most easily recognized characters of *Hymenasterides* are the alternating prominent and nonprominent adambulacral plates, correlated with the quadriserial arrangement of the tube feet.

Family ZOROASTERIDAE Sladen, 1889.

KEY TO THE KNOWN GENERA OF ZOROASTERIDAE.

a^1 Dorsal surface not devoid of spines and not covered with a smooth tough membrane in sharp contrast to the spiniferous or squamiferous actinolateral regions.

  b^1 Superambulacral plates absent; no conspicuous buttress connecting upper enlarged end of first 2 pairs of ambulacral plates with the body wall at interradial angle.

    c^1 All the adambulacral plates carinate on the furrow face. *Prognaster*[1] Perrier.

    c^2 Adambulacral plates alternately carinate and noncarinate on the furrow face.

---

[1] *Prognaster* Perrier, Comptes rendus, vol. 112, May 5, 1891, p. 1226. Type, *P. grimaldii,* monotypic. Also 1894, p. 120, where it is stated that the genus is new and where only one species, *P. longicauda,* is mentioned. In 1896 in Résultats des campagnes scientifiques du Prince de Monaco, fasc. 11, p. 22, *Prognaster* is redescribed, with *P. grimaldii. P. longicaudus* is probably not congeneric with *grimaldii.* The internal structure of both is unknown.

d^1 Rays long, slender, disk small; abactinal, marginal, and actinolateral plates arranged in regular longitudinal lines along ray, a series of adradial plates being always present; all but the median radial, or carinal, which are longer than the rest, form also transverse series with one another; plates covered with small papilliform skin-covered spinelets, and most of them bear an enlarged spine; papular areas small; forficiform pedicellariae present; actinolateral plates in 3 to 5 series, the upper subequal to the inferomarginal plates; superomarginal plates not conspicuously larger than inferomarginal plates____*Zoroaster* Thomson.

d^2 Abactinal plates arranged in regular longitudinal series (the carinal plates the largest), bearing large skin-covered scales, which mask all plates except some of the primary apical plates of disk, and the carinal series of ray; no pedicellariae; actinolateral plates in 2 or 3 series, much smaller than the inferomarginals; superomarginal plates much larger than inferomarginal plates. *Pholidaster* Sladen.

b^2 Superambulacral plates present; a conspicuous buttress, the specialized first superambulacral plate connects the upper end of the first 2 ambulacral plates with body wall at interradius.

c^1 Well developed adradial plates; with 2 series of well developed papular areas between the carinal and superomarginal plates, the latter not conspicuously enlarged nor overlapping the carinals. *Myxoderma* Fisher.

c^2 No adradial plates; 1 series of very small adradial papular pores; superomarginals alternating larger and smaller, overlapping strongly and dominating the carinals which are sunken below the level of the superomarginals___________________________________*Bythiolophus*, Fisher.

a^2 Abactinal plates of disk, the carinals, adradials (when present), marginals, and sometimes one series of actinolateral plates devoid of spines or any conspicuous armature but mostly smooth and covered with a tough membrane of variable thickness, often partly obscuring the plates; 2 to 4 lower series of actinolateral plates covered with squamiform fleshy spinelets and with sometimes a conspicuous appressed spine; superambulacral plates present, the first conspicuously enlarged into a buttress connecting upper end of first 2 ambulacral ossicles with the body wall.

b^1 With a series of adradial plates more or less well developed; 4 or 5 series of actinolateral plates______________________________*Cnemidaster* Sladen.

b^2 Adradial plates absent, the inner lobe of the superomarginal plates overlapping the carinal plates; 3 series of actinolateral plates with the beginning of a fourth in large examples___________*Mammaster*, Perrier.

Genus ZOROASTER Wyville-Thomson.

Zoroaster Wyville Thomson, Depths of the Sea, 1873, p. 154. Type, *Z. fulgens* Thomson.

KEY TO SPECIES HEREIN DESCRIBED.

a^1. Carinal, marginal, and lateral plates all with central spine; carinal spine, stout and conical; marginal and lateral spines acicular, prominent; pedicellariae long and slender, usually 4 times as long as width at base; miliary spinelets long, very slender, spaced_______________*ophiactis*, p. 473.

a^2. Superomarginal and proximal inferomarginals without central spine; lateral plates with prominent spines; carinals with inconspicuous central spine and several enlarged spinelets, or enlarged spinelets only; pedicellariae small, only slightly longer than width of base; miliary spinelets papilliform, close-set------------------------------------*philippinensis*, p. 477.

a^3. Carinal and all but distal superomarginal plates without central spine or enlarged spinules; inferomarginal and lateral plates with central spine; carinal plates very prominent, subquadrate, arched; adradial plates inconspicuous, nearly entirely covered by carinals and superomarginals; rays very long and slender (R=17 r); adambulacral plates with 2 transverse series of spines on actinal surface and 1 on the furrow keel of alternate plates; papular pores very small------------*microporus*, p. 475.

KEY TO THE INDO-PACIFIC SPECIES OF ZOROASTER.[1]

a^1. Carinal, marginal, and lateral plates all with central spine.

b^1. Carinal plates not unusually large; pedicellariae conspicuous.

c^1. R=9 r. Spinelets grooved; central spine of abactinal plates often obsolescent; pedicellariae more conspicuous than spines, except those of the 2 lowermost rows; prominent adambulacral plates with 2 large bunches of pedicellariae (12 to 20 to a bunch) deep in furrow. *alfredi* Alcock.

c^2. R=18 r. Spinelets not grooved; central spine of abactinal plates well developed; papular pedicellariae very slender, less conspicuous than spines, and less numerous than in *alfredi;* prominent adambulacral with a small group of pedicellariae on lowest furrow spine, not 2 large bunches ------------------------------------ *ophiactis* Fisher.

b^2. Carinal plates not unusually large; pedicellariae not conspicuous; subambulacral spinelets not in 2 definite transverse series.

c^1. R=16 r; rays hemicylindrical, depressed; madreporic body large, tumid, conspicuous; carinal spines conical, stout, fluted------*planus* Alcock.

c^2. R=10 to 11 r; rays strongly carinated; madreporic body small, inconspicuous; carinal spines small, not fluted----------*spinulosus* Fisher.

b^3. Carinal plates very large, tumid, vertebra-shaped, each with a globular or squatly conical spine; papular pores very small; adambulacral plates with 3 or 4 actinal spines in 2 transverse series, and prominent plates with 2 or 3 additional spines in the furrow, the outer with 1 large pedicellaria, the inner with 6 to 10 small ones--*angulatus* Alcock.

a^2. Superomarginal plates without central spine; carinal plates with small central spine and several enlarged spinelets, or with tuft of enlarged spinelets only.

b^1. Prominent adambulacral plates with 4 or 5 spines, 1 within furrow with 1 or 2 pedicellariae; pedicellariae fewer, small; inferomarginal plates with central spine------------------------------------*carinatus* Alcock.

b^2. Prominent adambulacral plates with 6 or 7 spines; at least 2 furrow spines with pedicellariae, the upper with a pedicellaria as long as spine; proximal inferomarginal plates without central spine; pedicellariae numerous, small------------------------------ *philippinensis* Fisher.

a^3. Carinal plates without trace of enlarged central spine.

b^1. Adradial plates conspicuous; carinal plates medium-sized, oval or rounded, granular; no superomarginal spines; R=12 r; papular pores medium-sized-- *adami* Koehler.

---

[1] *Z. tenuis* Sladen, from off the north coast of New Guinea, 1,070 fathoms, is too young to compare with these species. It belongs in section a^1.

b^2. Adradial plates inconspicuous, largely obscured by the large carinals; R=16 to 17 r; papular pores very small.
  c^1. Carinals hexagonal; 2 or 3 lateral rows of spines; 1 transverse series of subambulacral spines on both kinds of plates; rays hemicylindrical; tube feet quadriserial__________________________*barathri* Alcock.
  c^2. Carinals squarish; 5 lateral rows of plates with central spines; 2 transverse series of subambulacral spines on both sorts of plates; rays strongly carinated; tube feet biserial________*microporus* Fisher.

ZOROASTER OPHIACTIS Fisher.

Plate 135, figs. 2, 2*a–b*; plate 136, fig. 1; plate 139, fig. 3.

Zoroaster ophiactis FISHER, 1916*b*, p. 29.

Diagnosis.—Closely related to *Zoroaster alfredi* Alcock, from which it differs in having longer rays, stouter, conical, carinal spines, relatively smaller papular pedicellariae, ungrooved spinelets, less numerous adambulacral pedicellariae, and in lacking, deep in the furrow, the 2 large bunches of pedicellariae characteristic of *alfredi*. R=282 mm., r=15.5 mm., R=18 r. Breadth of ray at base, 17 mm. Disk very small, fairly level on top in large specimens, tumid in small; rays slender and strongly carinate, the carinal plates forming a definite spiniferous ridge; median tube-feet smaller and more crowded than the lateral.

Description.—Primary plates of disk fairly conspicuous, but, like the others, covered with slender, rather long hirsute spinelets, interspersed among which, on the papular areas, are several large 2-jawed pedicellariae. The primary plates bear a central robust spine, much stouter and a trifle larger than the spinelets. Carinal plates forming a conspicuous ridge, each with 2 lobes on either side which overlie and partly cover the small adradial plates. Between the adradial plates and adambulacrals, at base of ray, 7 series of plates, which are tumid and have 4 obtuse lobes by which they imbricate. The plates increase in tumidity toward the furrow. Plates covered with slender, relatively long, slightly spaced unequal spinelets, which, however, vary in length on different specimens, but are much longer and more hirsute than in the *carinatus* group. These spinelets increase slightly in length toward the furrow. Each carinal plate has a central robust conical spine or sharp, deciduous tubercle of variable length but very much thicker and usually decidedly longer than the spinelets. The other plates (except the small adradials) bear a central, conspicuous, slender, tapering, sharp spine, that of the superomarginal about 1 to 1.5 plates in length while those adjacent to the adambulacrals are 2.5 plates in length. The spines of the lower 3 longitudinal rows are flattened, appressed, and have lengthwise shallow grooves. The papular areas are fairly large in big specimens, with 1 or 2 papulae. Each area is guarded by

1 long, slender, pedicellaria, and sometimes by 1 or 2 additional small ones. The pedicellariae are frequently as long as the longest spinelets and the slender tips are often slightly curved. They usually stand on the lower, transverse lobe of a plate.

Prominent adambulacral plates with 1 spine deep in furrow armed with 1 to several pedicellariae at its base (not always present) and a terminal three-cornered sacculus covered with upward of 10 unequal, medium-sized, and small pedicellariae. This spine is usually bent toward the nerve cord. Above this a row of 4 or 3 spines is directed upward, the third usually the longest. The first, that above the true furrow spine, has a large pedicellaria, shaped like a miniature ibis beak, attached to its middle or its base. The second spine sometimes has a similar pedicellaria. The outer end of the plate has 1 or 2 spinelets and 1 or 2 small pedicellariae. The nonprominent plates have a small spine on the adoral furrow corner and on the surface of the plate a group of 4 or 5 spines and spinelets, 1 to 3 near the aboral marginal being of conspicuous size and sometimes forming an oblique series toward the outer adoral corner. Two or 3 small, slender pedicellariae stand on the outer margin of plate. The figures will best show the disposition of the adambulacral spines. See also the figures of a half-grown specimen with R, 115 mm.

Madreporic body, medium sized, convex about half the diameter of the adjacent basal plate.

Young.—A specimen from station 5299 has R=53 mm., r=5.5 mm., R=9.6 r. The carinal plates have a stout conical upright spine or tubercle, but the other central spines are very slender, that of the superomarginal scarcely longer than other spinelets on some plates. Five series of lateral plates, including superomarginals. Prominent adambulacral plates with transverse series of 3 or 4 spines, the innermost with 1 large pedicellaria. The large pedicellariae guarding the papulae are present only at the base of ray and on disk. Tube feet in 2 series.

Type.—Cat. No. 37008, U.S.N.M.

Type-locality.—Station 5606, Gulf of Tomini, Celebes, 834 fathoms, green mud; 1 specimen.

Distribution.—From southern Luzon to Celebes, 559 to 890 fathoms, bottom temperature 38.3° to 39.2° F.

Specimens examined.—Four, the type and 1 from each of the following stations:

Station 5299, China Sea, vicinity of southern Luzon (lat. 20° 05′ N.; long. 116° 05′ E.), 524 fathoms, gray mud, sand.

Station 5582, vicinity of Darvel Bay, Borneo, 890 fathoms, gray mud, fine sand, bottom temperature 38.3° F.

Station 5618, Buton Strait, Celebes (lat. 5° 35′ S.; long. 122° 20′ E.), 559 fathoms, green mud, bottom temperature 39.2° F.

Remarks.—The type of this species (or perhaps subspecies) is much larger than that of *Z. alfredi*, which measured R, 190 mm., and in which R equals 9 r. A specimen of *ophiactis* from station 5648 has R 120 mm. and R=12 r. Thus the ray is relatively longer than in *alfredi*, while in the type of *ophiactis* the ray is relatively twice as long, but the specimen is much larger. Alcock describes the disk pedicellariae of *alfredi* as being as large as grape stones. This is certainly very much larger than in *ophiactis*, where the longest, narrowly lanceolate as viewed from the side, measure 2 mm. They are usually about 1.5 mm. long. As for the pedicellariae of the rays, Alcock says that they are much more conspicuous than any of the spines except those on the plates of the 2 most actinal rows. This is not true for *ophiactis*. The pedicellariae are not so long as the spinelets, as a rule, and those which are longer than the spinelets are too slender to be very conspicuous. The stout carinal spines are much heavier than those of *alfredi* and much larger than any of the pedicellariae. There seems to be considerable difference in the details of the adambulacral armature.

Z. alfredi was dredged in the Bay of Bengal 1,300 to 1,380 fathoms, Globigerina ooze.

ZOROASTER MICROPORUS Fisher.

Plate 134, fig. 4, 4*a*; plate 136, fig. 2; plate 139, fig. 4.

Zoroaster microporus FISHER, 1916*b*, p. 30.

Diagnosis.—Related to *Zoroaster barathri* Alcock, from which it differs in having squarish instead of hexagonal carinal plates, smaller miliary spinelets, longer central spines on 5 lateral rows of plates (instead of on the 2 or 3 lowermost series only), more numerous pedicellariae, in having 2 inner spines of the prominent adambulacrals with pedicellariae (3 in *barathri?*), and in having 2 transverse series of spines on the actinal face of both sorts of adambulacrals. R=205 mm., r=12 mm., R=17 r; breadth of ray at base, 13 mm. Disk small, scarcely more than the united bases of the rays; rays long, slender, with a conspicuous, rounded, unarmed carinal ridge, and a well-defined sulcus along either side; 5 series of lateral plates with a central spine; tube feet biserial.

Description.—Major portion of abactinal surface of disk occupied by primary apical plates, forming 2 circles around the large tumid central plate (see figure). Plates covered with short papilliform spinelets spaced about half to two-thirds their length, the calcareous portion slender, but their membranous investment giving them an ovoid, often asymmetrical, form. No enlarged central spines. Two-jawed pedicellariae, slightly longer than the spinelets, rather numerous around the papulae and along the sutural lines. Papulae 1 or 2 to an area, small; pores very small. Carinal plates forming an evenly rounded, prominent, carinal ridge, the general form of the plates being square. The transverse sutures, which are arched, are nearly straight, while either border of the proximal plates is shallowly notched in the middle to accommodate a small papula, and each of the four corners of the plate is rounded, on account of a small adjacent papular pore. Beyond the basal third of the ray this notch disappears, on account of the absence of the pore (the corner pores persist irregularly far along ray) and the lateral borders of the plate are slightly convex. Proximally there are two transverse rows of lateral plates to each carinal, but the regularity is soon lost.

Adjacent to the carinals is a series of small, flat, sunken adradials, overlapped by the carinals and superomarginals, the widest being about one-third the width of the carinals. Between these and the adambulacrals are 6 series of regular broadly elliptical slightly tumid plates, wider than long and forming also regular transverse rows. The 2 upper series (the marginal plates) are not larger than the others, except that the 2 most actinal series are more covered by the overlapping of the adjacent plates above, and appear to be smaller. Very small papulae occur at the junction of any 4 plates, except adjacent to adambulacrals. The surface of the plates is covered with short, pointed, papilliform spinelets spaced one-half to two-thirds their length, and the inferomarginals, and the actinal intermediate plates (proximally 5 rows in all) have a central appressed, slender, needlelike spine, which on the inferomarginals is scarcely longer than the plate (and is sometimes obsolete), but increases in size regularly toward the furrow, the lowermost spines being 2 or 2½ plates long. Near the end of ray the superomarginals have also a small central spine. There are many small 2-jawed pedicellariae along the sutures between plates, especially near the papulae.

Prominent adambulacral plates with a transverse oblique series of 5 prominent spines, and adorally to the outer 2, a second transverse series of 2 much shorter spinelets. A similar additional spinelet sometimes stands at the outer end of the first series. The innermost spine, deep in the furrow, bears a saccular investment, with upward of 20 small pedicellariae, while the next spine, directed across furrow has at the middle or base a large pedicellaria, with slightly curved jaws as long as or a little longer than the spine. The nonprominent plates have on the actinal surface usually 5 spines, in 2 transverse series, the aboral the larger and containing 3. In the furrow, near the adoral margin, on a level with the second spine of a prominent plate (that bearing a large pedicellaria) is a short spine with a bunch of 6 or 8 small pedicellariae. Proximally, along the suture between the adambulacral and intermediate plates is a row of small pedicellariae, 1 to 3 to each adambulacral plate. Sometimes they stand on an intermediate plate. Furrow narrow, tube feet in 2 series; the pedicels opposite prominent plates are smaller than the others, and a trifle out of line at the base of the ray.

Madreporic body small, about one-third the diameter of the adjacent basal plate.

Type.—Cat. No. 37009, U.S.N.M.

Type-locality.—Station 5637, 21 miles southwest of Amblan Island (off Bouro Island), Moluccas (lat. 3° 53′ 20″ S.; long. 126° 48′ E.), 700 fathoms, gray mud; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—Among the species described by Alcock from the Bay of Bengal and adjacent waters this species stands nearest to *Z. barathri*, dredged in 1,520 fathoms in the Bay of Bengal. It differs from *Z. planus* (Laccadive Sea, 1,200 fathoms) and *Z. angulatus* (Gulf of Manaar, 597 fathoms) in lacking the series of conical carinal spines. In addition, *Z planus* has hemicylindrical depressed rays, a very large madreporic plate, and central spines on the superomarginals as well as on the other lateral plates, while the adambulacral plates do not have 2 transverse rows of spines on the actinal face. The disk is very definitely delimited from the base of the rays, the covering of spinelets is sparser, and the central spines are longer. *Z. angulatus* agrees in having the double series of subambulacral spines, but differs in the distribution of adambulacral pedicellariae, has superomarginal central spines, and quadriserial tube feet.

ZOROASTER CARINATUS PHILIPPINENSIS Fisher.

Plate 116, fig. 3; plate 135, figs. 3, 3*a*; plate 137.

Zoroaster carinatus philippinensis Fisher, 1916*b*, p. 30.

Diagnosis.—Differing from *Z. carinatus* (Andaman Sea) in having more numerous adambulacral spines (6 or 7 instead of 4 or 5), with many more pedicellariae; less tumid apical plates, less prominent central spinelets to carinal plates; more numerous pedicellariae generally. Disk small, rays long, slender, pointed, with a midradial ridge or carina; central spinelets of carinal plates slightly enlarged; 4 rows of slender appressed spinelets along side of ray (3 in small specimens); superomarginal and proximal inferomarginal plates without central spine (the latter sporadically with a spine in *carinatus*); prominent adambulacral plates with transverse series of 6 or 7 spines (5 in small specimens), the inner 2 with several large and small pedicellariae; R=194 mm., r=13.5 mm., R=14 r; breadth of ray at base, 14 or 15 mm.

Description.—Disk flat-topped, or only slightly domed, and elevated above midradial ridge of ray. Primary apical plates not prominent, except in small specimens, and in large specimens not very distinct one from another, the borders being obscured by the dense covering of small, papilliform, blunt or sharp, spinelets (1 mm. long in the type). These spinelets are usually more or less swollen on account of their membranous covering and are inclined slightly toward the center of disk, the 2, 3, or 4 central spinelets of each plate being, as a rule, enlarged slightly, especially in large specimens. One of the central spinelets may surpass the others a trifle and be more tuberculate in form, but usually the excess is not at all conspicuous. One or 2 small lanceolate forficiform pedicellariae about as long as the spinelets, but more robust, stand on the edge of the papular areas, which in the type usually contain 2 or 3 papulae, but in moderate or small-sized examples has generally 1 papula. In medium-sized specimens the spinelets are decidedly granular in appearance, owing to the fact that they are relatively shorter and nearly always blunt or truncate.

Degree of carination of ray variable, best marked in medium-sized specimens (R, 125 mm.) and in large specimens such as the type it is rather more pronounced on the proximal part of the ray. Arrangement of plates and spinelets closely similar to that of *Z. carinatus*, but in specimens with R more than 90 mm. there are 6 longitudinal series of plates between the adradial and adambulacral plates, instead of 5 as described for *carinatus*. In the present species some specimens of the size of the type of *carinatus* (R=90 mm.) have 5 series and some 6. Plates of carinal series slightly wider than long, or the 2 dimensions subequal, with 1 or 2 lobes on either side, which overlap the sunken adradial plates, the exposed surface of the latter being one-third or one-half the width of the carinal plates. The next 2 series probably represent the marginal plates. They are wider than long, hexagonal, and the upper series overlaps the adradial plates and the inferomarginals. The exposed surface of the plates of the remaining 4 rows decreases in width as the furrow is approached, and each bears a sharp, appressed, dagger-shaped spine, which increases in size toward the furrow, where they are about twice the length of their plate. These spines thus form vertical series of 4 along the side of the ray. Toward the end of the ray, after the lowermost series of plates ends, the spines appear on the inferomarginal plates, and sometimes occur here and there, but not numerously, on the proximal inferomarginals. The superomarginals are without central spines.

All the plates are closely covered with pointed, appressed, papilliform spinelets, which are directed toward the midradial line, 3 or 4 in the center of the carinal plates being enlarged, and forming an inconspicuous tuft. The central spinelet may be enlarged into a short, robust, bluntly pointed tubercle. In some specimens the spinelets of the superomaringal plates increase slightly in size toward the inner margin, but there is much variation in this character. There are 7 series of papular pores, but the lowest are very small. Most of the pores are guarded by 1 or 2 pedicellariae, subequal to the spinelets, or larger. There is considerable variation in their occurrence. Sometimes nearly all the pores are guarded, at least on the proximal half of ray, while in others less than half. Pedicellariae sometimes occur proximally on the transverse sutures between the carinal plates.

Prominent adambulacral plates of type with a transverse series of 6 or 7 spines, 3 or 4 on the projection. There is usually 1 deep in the furrow, with a large, and 1 or more small, pedicellariae at the tip (or small pedicellariae only). Above this forming a nearly vertical series are 3 other spines, usually flattened. The lowest has a large pedicellaria as long as the spine, sometimes with additional small ones; the next 2 are usually without pedicellariae. Two or 3 shorter spinelets follow, on the actinal surface of the plate, but in line with the foregoing, while 2 or 3 (or less) additional spinelets form an independent transverse series adorad to the outer 2 of the principal series. These 4 or 5 spinelets form a group, and are subequal to the spinelets of the adjacent actinal plates. The nonprominent plates have a group of 4 or 5 spinelets subequal to the outer spinelets of the prominent plates. One stands on the furrow margin, adjacent to a tube foot, and has 1 or 2 medium-sized pedicellariae at the tip. In a large specimen from station 5326, the 3 inner spines of each prominent plate are provided with pedicellariae. Many plates have only the single transverse row of spines without the additional adoral spinelets. In small specimens, the pedicellariae tend to be relatively smaller. There is considerable variation in the relative numbers of large and small pedicellariae, but they are much more numerous than in *Z. carinatus*. In some specimens pedicellariae are lacking on the nonprominent plates.

Madreporic body small, about half as broad as adjacent basal plate.

Young.—The smallest specimen (station 5453), and the only one with 6 rays, measures R, 24 mm., r, 3.5 mm., R=6.8 r. The carinal plates are conspicuous, and touch the superomarginals. In addition to the inferomarginals there are a series of actinal intermediate plates, the inner of which extends two-thirds the length of ray. These plates bear a central spine as in the adult, and the central spinelets of the carinal plates are slightly enlarged. Four series of papulae—one on either side of the carinal plates, and one intermarginal. The prominent adambulacral plates have 3 permanent spines in the furrow, the lowest with 1 or 2 pedicellariae, and on the actinal surface 2 or 3 additional spinelets, 1 usually out of line. The other plates have 3 to 5 spinelets. the one on the furrow usually with a small pedicellaria. Terminal plate large.

Type.—Cat. No. 37010, U.S.N.M.

Type-locality.—Station 5587. Sibuko Bay, Borneo. 415 fathoms, green mud, sand, coral, bottom temperature 42.3° F.; 1 specimen.

Distribution.—Philippine Islands, from northern Luzon to Tawi Tawi, and Sibuko Bay, Borneo. 96 to 604 fathoms, usually on green mud.

Specimens examined.—Ninety, from the following stations:

Specimens of Zoroaster c. philippinensis examined.

Station.	Locality.	Depth (fathoms).	Nature of bottom.	Bottom temperature ° F.	Number of specimens.
5123	Off Malabrigo Light, east coast Mindoro	283	Green mud	....	3
5124	Off Point Origon, east coast Mindoro	281	Soft green mud	....	1
5183	Between Panay and Negros	96	.....do	63.4	3
5215	East of Masbate Island	604	Green mud	50.5	2
5216	Between Masbate and Luzon	215	.....do	63.1	1
5259	Off northwestern Panay	312	Gray mud, globigerina	49.3	1
5265	Batangas Bay, Luzon	135	Sand, mud	....	2
5268	.....do	170	Sand, pebbles	....	14
5272	China Sea, off Corregidor Light, Luzon	118	Mud, shells, coral sand.	57.4	2
5273	.....do	114	.....do	....	3
5278	China Sea, between Lubang Island and Manila Bay.	102	Fine sand, mud, shells.	59.6	5
5282	.....do	248	Dark gray sand	47.4	1
5297	Off Batangas Bay (Verde Island Passage)	198	Mud, sand	....	6
5298	.....do	140	Sand	....	1
5325	Off Hermanos Island, northern Luzon	224	Green mud	53.2	1
5326	.....do	230	Mud	55.4	15
5371	Off Tayabas Light, Marinduque Island	338	Soft mud	....	1
5388	Between Burias and Luzon	226	Soft green mud	51.4	1
5411	Between Cebu and Bohol	145	Green mud	55.2	2
5412	.....do	162	.....do	54.8	1
5417	.....do	165	Gray mud, sand	54.4	5
5418	.....do	159	.....do	54.4	1
5453	Albay Gulf, southern Luzon	146	....	....	4
5476	San Bernardino Strait	270	Fine sand	48.3	2
5527	Between Siquijor and Bohol Islands	392	Globigerina ooze	53.3	3
5528	.....do	439	.....do	53.3	2
5538	Between Negros and Siquijor	256	Green mud, sand	53.3	2
5565	Between Jolo and Tawi Tawi	243	Sand, Pteropod shells.	52.3	3
5587	Sibuko Bay, Borneo	415	Green mud, sand, coral.	42.3	1
5589	.....do	260	Fine gray sand, gray mud.	45.7	1

Genus CNEMIDASTER Sladen.

Cnemidaster SLADEN, 1889, p. 423. Type, *C, wyvillii* Sladen.

CNEMIDASTER WYVILLII Sladen.

Plate 134, figs. 3, 3*a*; plate 138.

Cnemidaster wyvillii SLADEN, 1889, p. 424, pl. 67, figs. 3 and 4; pl. 68, figs. 3 and 4.

The genus *Cnemidaster* Sladen was based upon a single, very immature specimen of the present species, dredged by the *Challenger* in 800 fathoms in the Arafura Sea. The measurements of this type are: R, 22 mm., r, 4.25 mm. The smallest specimen in the *Albatross* collection has R=33 mm. When adult, *Cnemidaster* bears a very close resemblance to *Mammaster* Perrier, the only differential characters that I can find being stated in the key to genera. It may be necessary eventually to merge the 2 genera. Perrier (1894, p. 128) states that there are *forcipiform* (croisé) pedicellariae on the disk; I have found numerous forficiform pedicellariae. The former are not supposed to occur in this family.

In both *Cnemidaster* and *Mammaster* superambulacral plates are present and the first is modified into a conspicuous buttress or stay extending from the upper end of the combined first 2 ambulacral plates to the body wall at the interradius, as in *Myxoderma* and *Bythiolophus*.

There are in the collection no specimens strictly comparable with the very small type of *wyvillii*, although 1 example, as already stated, is only slightly larger. This specimen seems to be referable to Sladen's species, although it must be admitted that the specific determination of very young specimens is difficult, owing to the fact that important characters, such as granules, spines, and pedicellariae may not appear until comparatively late. The young of different species may, therefore, be very closely similar. Owing, however, to the similarity between the 2 forms, and the geographical proximity of the *Challenger* station, I have thought it better to list the *Albatross* specimens as *wyvillii*. They are closely related to both *Cnemidaster zea*, and *C. squameus*. For instance, there is considerable variability, one specimen, otherwise perhaps referable to *C. zea* has central spines on the distal carinal and marginal plates, and spaced granules on the disk plates, while another from the same station (5602) has no granules on the swollen disk plates. The following description will aid in determining specimens:

Description.—Taken from specimens from Gulf of Tomini, Celebes. R=109 mm., r=12 mm., R=9 r (station 5607). Disk flat-topped and elevated above base of rays, the plates essentially as in the young, but definitely scalloped or indented for papulae. In the grooves are a few fair-sized pedicellariae (1.5 mm. long) about 3 times as long as broad at base, and a few scattered immersed granuliform spines. One specimen from station 5602 has scattered small granules under the skin of the disk and proximal abactinal plates of the ray, while another from station 5606 has fewer granules on the disk only. Four other adult specimens, one from 5602, lack the granules. Rays evenly arched, without a marked carinal ridge. There is a carinal series of slightly convex plates proximally wider than long, distally longer than wide. On either side of this is a close double row of papular pores emerging on either side of a nearly hidden series of small adradial plates. Then follows 3 (or 4) series of overlapping, smooth, skin-covered plates, followed by 3 series covered with spaced, lanceolate, flat, squamiform spinelets, which in the interbrachial areas cover the first 1 or 2 plates of the other series, as far up as the lower border of the superomarginals. These three lower series (or 2 in smaller examples) have a central flattened, sharp spine on many of the plates, often arranged so that alternate transverse rows lack one, or all of the central spines, which are therefore in spaced, often incomplete transverse combs. On the outer third of the ray the carinal and marginal plates (the latter being the only naked plates reaching end of ray) are armed with an appressed, tapering, sharp spine about as long as its plate. There is no trace of this on the young specimen, although present on an adult from the same station (5607). Very small pedicellariae occur sparingly on the 3 lower rows of armed plates, and distally on the abactinal naked plates.

Prominent adambulacral plates with a transverse series of 4 or 5 spines, the innermost rather deep in the furrow and directed horizontally between 2 tube feet; the next 2 longer, erect, flattened, acute, slightly curved, and tapering from a stout base; the outer 1 or 2 shorter, flattened, and more or less leaflike. The innermost 2 spines (or the second only) bear each a large pedicellaria, frequently as long or even longer than the spines, and sometimes accompanied by one to several small pedicellariae, especially at the base of the ray. One jaw of the pedicellaria is spatulate, larger, and more curved than the other, resembling a miniature duck's beak; or the jaws are nearly equal and the distal half of the pedicellaria is curved, something like a miniature ibis's beak. Along the adoral, transverse margin are usually two squamiform spinelets. In the specimen with granular disk plates from station 5602 there are sometimes 3 spinelets in this series, and the one nearest furrow is tapered and bears one small pedicellaria (or at the base of the furrow, several). Nonprominent plates with usually 5 spines, in 2 transverse series (3 spines in the adoral). Usually the 2 aboral spines are flattened and squamiform, and the adoral tapered but often the outermost of the adoral spines is also squamiform. The innermost of that series is short, tapered, and stands a little out of line on the furrow margin of plate. It usually (but not always) bears a pedicellaria longer than the spine, solitary or accompanied by 1 to 3 very small ones at its base.

In the young specimen from station 5202 the plates are subequal and armed with a transverse series of 4 or 5 spines, the innermost slender, tapering, and sharp, the others increasing in thickness and becoming more flattened toward the outer end of the plate. Adorad to these there is often but not always 1 short spinelet, rarely 2. Sladen mentions, in the description of the immature type, only the series of 5 spines, but his figure (1889, pl. 68, fig. 4) shows the small adoral spinelet.

Madreporic body small (1.5–2.5 mm.), and surrounded by granules or very short, stubby spinelets. Tube feet in 4 crowded series proximally, becoming 2 on the outer third or two-fifths of ray. There are small triangular superambulacral plates. Ampullae double, but the outer division very short, while the inner is vermiform and 3 or 4 times as long.

Specimen from vicinity of Darvel Bay, Borneo, station 5582.—R=205 mm., r=17 mm., R=12 r. In this example there is no sign of granulation on the abactinal plates of the disk and only the last dozen marginals at the tip of ray have an inconspicuous armature. The superomarginals usually have 2 appressed spinelets, and the inferomarginals 1. On the basal third of the ray there are 4 lateral series of naked plates, covered with smooth skin, then 3, and finally near the tip of ray, 2. The enlarged central spine of the 3 actinal intermediate series occurs almost always only on alternate transverse (or vertical) series. The prominent adambulacral plates have generally a transverse series of 4 spines, the furrow spine only bearing an equally long pedicellaria with jaws curved at the ends, accompanied by 1 or 2 small ones. The 2 outer spines are flattened and squamiform, while the second is intermediate. There are 2 much shorter lanceolate leaflike spinelets adoral to the spines. The nonprominent plates have 5 squamiform spines, but the furrow spine has a pedicellaria only irregularly and at the base of ray.

This example is extremely close to *Cnemidaster zea* (Alcock), the only difference of importance seeming to be the restriction of the lateral spines to alternate vertical rows of plates. The description of *zea* does not particularize on this feature, so that the arrangement may be somewhat irregular, as in the specimens from the Gulf of Tomini. Of the adambulacral armature of *zea*, Alcock says: The adambulacral plates are covered with flat foliaceous spinelets; every alternate plate has a prominent intraambulacral ridge, bearing a row of 3 saber-shaped spines, and deep within the furrow a slender spinelet furnished with several pedicellariae one of which is large." The type of *zea* has R, 144 mm., r, 12 mm.

Type.—In the British Museum (Natural History).

Type-locality.—*Challenger* station 191, Arafura Sea, northwest of the Aru Islands (lat. 5° 41′ S.; long. 134° 4′ 30″ E.), 800 fathoms, green mud, bottom temperature 39.5° F.

Distribution.—Vicinity of Darvel Bay, Borneo; Gulf of Tomini, Celebes; Arafura Sea; 761 to 1,089 fathoms; temperature range, 36.3° to 39.5° F.

Specimens examined.—Seven, from the following stations:

Station 5582, vicinity of Darvel Bay, Borneo, 890 fathoms, gray mud, fine sand, bottom temperature 38.3° F.; 1 specimen.

Station 5602, Gulf of Tomini, Celebes (lat. 0° 22′ N.; long. 132° 03′ 30″ E.), 962 fathoms, gray mud; 2 specimens.

Station 5606, same locality, 834 fathoms, green mud; 1 specimen.

Station 5607, same locality, 761 fathoms, fine sand; 2 specimens.

Station 5608, same locality, 1,089 fathoms, gray mud, bottom temperature 36.3°; 1 specimen.

Genus PHOLIDASTER Sladen.

Pholidaster Sladen, 1889, p. 426. Type, *Ph. squamatus* Sladen, first species; not designated. (See also 1885, p. 616, no binomial.)

PHOLIDASTER SQUAMATUS Sladen.

Pholidaster squamatus Sladen, 1889, p. 427, pl. 67, figs. 5 and 6; pl. 68, figs. 5 and 6.

Specimens examined.—Sixty-two from the following stations:

Station 5212, east of Masbate Island, Philippines, 108 fathoms, gray sand and mud; bottom temperature, 59.9° F.; 35 specimens.

Station 5214, east of Masbate Island, 218 fathoms, green mud; bottom temperature, 51.4° F.; 1 specimen.

Station 5391, between Samar and Masbate, 118 fathoms; 1 specimen.

Station 5392, between Samar and Masbate, 135 fathoms, green mud, sand; 13 specimens.

Station 5393, between Samar and Masbate, 136 fathoms, hard sand; 12 specimens.

Type.—In the British Museum (Natural History).

Type-locality.—*Challenger* station 204, off Tablas Island, Philippine group (lat. 12° 43′ N.; long. 122° 9′ E.) 100 fathoms, green mud.

Distribution.—Known from the central part of the Philippine group, 100 to 135 fathoms, mud and hard sand.

Remarks.—These specimens are from near the type-locality and agree well with Sladen's description and figures cited above. There are no superambulacral plates in this species.

Genus BYTHIOLOPHUS Fisher.

Bythiolophus Fisher, 1916*b*, p. 31. Type, *B. acanthinus* Fisher.

Diagnosis.—In general structure resembling *Zoroaster*, except in the presence of subambulacral plates, in the specialization of the first superambulacral plate as a conspicuous buttress running from the body wall at the interradius to the upper end of the 2 first ambulacral ossicles, and in the arrangement of the abactinal skeleton. In this the adradial series is more prominent than the carinal, consisting of alternately larger and smaller, transversely elongated plates, the larger of which overlie the lateral third of the carinals; both sorts strongly overlap the upper end of the superomarginals. Two series of marginal, and 4 series of intermediate plates. Adambulacral plates as in *Zoroaster*.

Remarks.—In *Zoroaster* the carinal plates are always larger than the adradial plates. The latter are very often nearly hidden by the carinals and superomarginals which overlap them. In the present genus just the reverse is the case. The adradials are large and rest upon the superomarginals and carinals. In the arrangement of the dorsal skeleton *Pholidaster* and *Cnemidaster* are in essential agreement with *Zoroaster.*

BYTHIOLOPHUS ACANTHINUS Fisher.

Plate 135, figs. 1, 1*a–c*; plate 139, figs. 1, 2.

Bythiolophus acanthinus FISHER, 1916*b*, p. 31.

Diagnosis.—Rays 5. R=105 mm., r=13 mm. R=8 r; breadth of ray at base, 14 mm. Rays 4-sided, very gradually tapering; abactinal surface of ray sunken along median line except near tip, where the surface is nearly plane; sides forming a steep bevel; interbrachial arcs angular; radial plates sunken, but tumid, with a short, sharp appressed spine; adradial plates prominent, forming margin of abactinal surface, larger and smaller alternating, the larger and some of the smaller with a central spine similar to the carinal spines; 6 lateral series of plates, each with a prominent central spine, the third and fourth from top the longest; prominent adambulacral plates with transverse series of 4 pines, and about 3 spinelets (on actinal surface), the inner with 1 to several pedicellariae.

Description.—Disk distorted, but apparently subplane abactinally, like the rays. The primary plates are not especially prominent. Disk plates with a central, short, sharp, lanceolate spinelet 1.5 mm. long, borne on a well-marked boss or mamelon. General surface of all plates of disk and rays covered with slender sharp membrane-invested spinelets about 1 mm. long and spaced one-third to one-half their length. On the disk they are a little stouter and the membrane a little thicker than on the rays. Three or 4 stout, broadly lanceolate pedicellariae surrounding each papula of the disk.

Rays 4-sided, the side walls forming a steep bevel with abruptly rounded upper and lower margins. Carinal plates tumid, broader than long, overlapped by either adradial series, the plates of which are much more prominent and decidedly broader than the exposed portion of the carinals and form the margin of a shallow sulcus, at the bottom of which are the tumid carinals. These adradial plates are much broader than long and are of two sorts, larger and smaller alternating (with some irregularities), the larger being roughly lozenge-shaped or elliptical, the smaller irregularly elliptical and wedged between the outer half or two-thirds of a couple of larger plates. Opposite the inner end of a small plate is a large papular pore, there being thus a series along either side of the carinal plates. Between the adradial and adambulacral plates are 6 regular longitudinal series, the plates of which also form regular vertical series, which correspond fairly regularly to the adradial plates. The 2 upper series represent the marginals, which are larger than the plates of the 4 inferior rows, the superomarginals being slightly smaller than the smaller adradial plates, and the inferomarginals a trifle smaller than the superomarginals. A series of tiny papulae is present between the adradial and superomarginal plates, another between the marginals, a third below the marginals (not complete) and a fourth, very incomplete, between the first 2 intermediate rows. Each carinal and adradial plate bears a sharp, appressed, lanceolate spine similar to those of disk, and forming 3 series along the dorsal surface of ray, the outer series being on the margin between the dorsal and lateral faces of the ray. On the distal adradial plates the spinelets are arranged in 2 transverse series, and on the last 25 in a single series. The marginal plates bear each a slender, needle-like spine, that of the inferomarginals being proximally one and a half or two times the length of the superomarginal or about 3 mm. This spine increases in length to about 5 mm. along the middle third of the ray, then decreases, while the superomarginal spine remains 1.5 to 2 mm. long until near the end. Each of the intermediate plates bears a large flattened, slender, sharp, appressed spine borne on a prominent boss which occupies most of the available surface of the plate. The spines are arranged thus in vertical series of 4 proximally and 3 distally; the upper is 5 to 5.5 mm. long, the next subequal or a little shorter (especially distally); the third, 3.5 to 4 mm., and much slenderer, while the lowermost is about 3 mm., and still slenderer. These spines which are in line with the marginal spines form a dense armature all along the side of the ray. Two or 3 short, stout pedicellariae a trifle shorter than the spinelets guard the dorsal papulae, while usually 1, but occasionally 2, occur close to the lateral papulae of the 2 upper series. The lower row of these 2 extends only a short distance along ray.

Prominent adambulacral plates have a single series of 3 slender spines directed into the furrow, the middle the longest; on the actinal surface are 1 or 2 spines (similar to the foregoing, and in line with them) and 3 shorter spinelets, the 4 or 5 forming 2 transverse series. The innermost furrow spine has 1 to 4 pedicellariae at the tip, the largest about one-half to three-fourths the length of the spine. Non-prominent plates with 4 spinelets surrounding a subcentral spine. A spinelet on the furrow margin carries 1 or 2 small pedicellariae. The inner furrow spine of the first 4 or 5 plates has numerous pedicellariae, while those on the mouth plates proper have upward of 40. These form a circle surrounding the mouth, the clusters touching one another. Tube feet in 4 series for three-fourths the length of ray.

Madreporic body small, convex, very inconspicuous. There are short superambulacral plates passing from the ambulacrals to the inferomarginals. The first superambulacral is much enlarged and acts as a stay or buttress connecting the upper swollen end of the first 2 ambulacral ossicles with the body wall at the interradial angle. Between this buttress and that of the adjacent ray is a very small membranous interbrachial septum. At the base of the ray the ambulacral ridge bends sharply upward, a fact which renders the buttress rather conspicuous.

Type.—Cat. No. 37011, U.S.N.M.

Type-locality.—Station 5648, Buton Strait, Celebes, 559 fathoms, green mud, bottom temperature 39.2° F.; 1 specimen.

Distribution.—Known only from type-locality.

Family ASTERIIDAE Gray (emended).

Genus DISTOLASTERIAS Perrier.

Distolasterias PERRIER, 1896, p. 34. Type, *Asterias* (*Stolasterias*) *stichantha* Sladen.

DISTOLASTERIAS EUPLECTA Fisher.

Coscinasterias (*Distolasterias*) *euplecta* FISHER, 1906, p. 1105, pl. 41, figs. 4, 4*a–c*; pl. 42, figs. 1–4.

The specimen, which measures R, 155 mm., and r, 9 mm., is larger than the type, with relatively smaller disk. The adambulacral spines are a trifle more attenuate and tapered (with compressed tip) at the base of the ray than are those of the type. Distally the spines are less compressed than those of the type, most of them being practically terete. One or 2 actinal intermediate plates on each ray carry, abnormally, a small spine, where in *hypacantha* there is regularly a spine.

Type.—Cat. No. 21188, U.S.N.M.

Type-locality.—Station 3885, Pailolo Channel, Hawaiian Islands, 136 to 148 fathoms, sand and pebbles, bottom temperature 61.8° F.

Specimen examined.—One from station 5371, northwest of Marinduque Island (lat. 13° 49′ 40″ N.; long. 121° 40′ 15″ E.), 83 fathoms.

Distribution.—Hawaiian Islands and Philippine Islands. The vertical range in the Hawaiian Islands is 63 to 182 fathoms.

DISTOLASTERIAS HYPACANTHA Fisher.

Plate 141, figs. 2, 3; plate 151, figs. 5, 5*a*.

Distolasterias hypacantha FISHER, 1917*b*, p. 92.

Diagnosis.—Rays 5. R=129 mm., r=8 mm., R=16 r; breadth of ray at widest part near base, 14 or 15 mm. Resembling *D. mazophora* (Alcock) and *D. euplecta* Fisher, from both of which it differs in having, on the proximal half of the ray, a series of small spines between the adambulacral spines and the inferomarginal spines (of which there are 2). On the abactinal surface, between the 2 superomarginal series, are 3 series of spines proximally, and only 1 (the carinal), distally; only 1 kind of major pedicellariae present, slender and lanceolate in form; rays pentagonal in section, the width of the lateral face proximally being about two-thirds that of either dorsal face (between superomarginal and carinal row of spines) while distally all four are nearly equal; disk very small, sunken below the dorsal surface of rays; rays constricted at base.

Description.—Plates arranged as follows: A carinal series, and on the dorsolateral angle of the ray a superomarginal, alternate plates of each series bearing a conical sharp spine; nearly midway between the two, a series of usually 3-lobed, much smaller, adradial plates, bearing somewhat irregularly a small conical spine on the proximal half of ray, and extending nearly to the tip of ray. Frequently they are so arranged that the alternate plates are connected with the carinals either directly by a dorsal lobe or by a short elliptical intermediate ossicle, while the other plates are joined to the superomarginals by a longer intermediate ossicle. Actinolateral border of ray very abrupt and formed by the inferomarginals, each bearing 2 slightly tapering flattened truncate or blunt spines in an oblique series, the outer a little longer, and above and adorad to the other. Extending two-thirds the length of the ray, between the inferomarginals and adambulacrals is a single series of small plates which are separated one from another by a papular area equal to their own length and extending two-thirds the length of the ray. For a third or a half the length of ray (depending upon size of specimen) each intermediate plate bears a small acicular spine about three-fourths the length of the outer adambulacral spine. The base of the innermost marginal spine is spaced from the outer furrow spine about the length of the latter.

The abactinal and superomarginal spines are surrounded by a basal sheath closely crowded with small forcipiform pedicellariae, while only the upper side of the upper inferomarginal spine is so provided—there being but a half circle of pedicellariae. These pedicellariae are about 0.35 mm. long, have about 5 lateral teeth and a broad terminal portion armed with many small teeth. There is but one sort of major pedicellariae—in form, slender, lanceolate, and pointed—scattered rather numerously on the abactinal and actinal surface. There are 2 series of papular areas between the carinal and each superomarginal series of plates, each with about 10 to 15 papulae; an intermarginal series on each side with 5 to 8 papulae to the area; and an actinal series alternating with the actinal intermediate spines with 1 to 5 papulae to an area extending about half the length of ray.

The integument is marked by fine channels, somewhat irregular, extending from the carinal plates to the inferomarginals. There are usually 2 of these lines between the superomarginal spines.

Adambulacral spines 2, slender, flattened, slightly tapered, and truncate. The inner is a little shorter than the outer, which is equal to about the length of 4 plates. On the furrow face of about every other plate, or sometimes on that of several consecutive plates, is a fair-sized, pointed, lanceolate, forficiform, pedunculate pedicellaria.

Each mouth plate with 2 spines at the inner actinostomial end: a short one, with 2 pedicellariae at the base, directed across mouth of furrow, and the second, over twice as long and much heavier, flattened and truncate, directed, with its near neighbor of the other plate, over the mouth. At the outer end of each plate an upright, flattened, sometimes subspatulate suboral nearly or quite as long as the longer apical spines.

Type.—Cat. No. 37032, U.S.N.M.

Type-locality.—Station 5417, between Cebu and Bohol, 165 fathoms, gray mud and sand, bottom temperature 54.4° F.; 1 specimen.

Distribution.—Known only from near type-locality, 88 to 165 fathoms.

Specimens examined.—In addition to the type, 1 from station 5415, between Cebu and Bohol (near type-locality), 88 fathoms, fine sand, bottom temperature 62.4° F.

Remarks.—This species closely resembles *D. eustyla* (Sladen), which is known only from the vicinity of Tristan da Cunha. Both species have a single series of actinal intermediate spines, but in *eustyla*, judging from Sladen's figure, the series extends practically to the tip of the ray. Sladen mentions these as a third inferomarginal spine, but they seem to belong rather to actinal intermediate plates. In *hypacantha* the inferomarginal spines are more spaced from the adambulacral spines, the major pedicellariae are much more numerous, and are present on the actinal surface, as well as in the furrow, the rays are longer. *D. dubia* Clark, from Botany Bay, has shorter, relatively stouter rays, stouter abactinal skeleton, larger major pedicellariae, broader and more flattened outer inferomarginal spines, deeply furrowed on the actinal side. *D. mazophora* (Alcock), *D. euplecta* Fisher, and *D. mollis* Hutton lack the actinal intermediate spines of *hypacantha*. In *D. euplecta* the inferomarginal spines are closer to the furrow spines than in *hypacantha*, the actinal intermediate plates being smaller and more tightly wedged between the adambulacrals and inferomarginals.

Genus TARSASTER Sladen.

Tarsaster Sladen, 1889, p. 439. Type, *T. stoichodes* Sladen.

TARSASTER DISTICHOPUS Fisher.

Plate 141, fig. 1; plate 155 ,figs. 3, 3*a–c*.

Tarsaster distichopus Fisher, 1917*b*, p. 92.

Diagnosis.—Rays 5. R=48 mm., r=5 mm., R=9.6 r; breadth of ray at base 6.5 mm. Disk very small, convex; rays long, slender, bluntly pointed; abactinal surface prominently arched, with a very slight midradial carinal ridge; actinal surface nearly plane, the sides of ray as defined by the 2 series of marginals, nearly perpendicular, but sloping inward toward the furrow, slightly. Differing from *Tarsaster stoichodes* Sladen in having 1 adambulacral spine, 1 spine on the midradial plates, prominent, unguiculate forficiform pedicellariae in the furrow, and biserial tube feet.

Description.—Plates arranged as follows: a carinal, a superomarginal, and an inferomarginal regular longitudinal series of 4-lobed, strongly imbricating plates, the transverse lobes nearly obsolete on the inferomarginals, which are contiguous to the adambulacrals (no actinal intermediate plates present). Between the carinal series and the superomarginals, for the proximal half of the ray, there are 2 not very regular series of smaller 4-lobed and 3-lobed plates, which on the distal half of the arm are reduced to a single series. These plates imbricate directly with one another in a longitudinal direction, as in the case of the carinals and marginals, but laterally they join the superomarginals on the one hand and the carinals on the other by one or, sometimes proximally, by two elliptical secondary ossicles, as shown, perhaps, better in the figure than by description. There are thus proximally 3 dorsolateral series of papular areas and distally 2, containing 1 or 2 papulae, while there is, in addition, on each side, an intermarginal series of smaller areas with 1 papula to an area. The small disk is composed chiefly of primary apical plates, not very regularly arranged, with 1 or 2 papulae in the intervening areas.

The carinal plates, the dorsolaterals, the superomarginals, and the secondary elliptical, or smaller connecting, plates each bear a short conical spine on a central boss of the plate, those of the dorsolaterals and secondary ossicles being one-half to two-thirds the size of the other spines, which are 1.25 to 1.5 mm. long. The inferomarginals (except the first plate) have each a stouter spine 2 mm. long, the series standing on the actinolateral margin of the ray. Each plate also carries, scattered over its surface, 3 to as many as 6 or 8 conspicuous, ovoid (as seen from side) forcipiform pedicellariae, usually about 0.45 mm. long. They give the appearance of an open, rather uniform, granulation to the half-dry specimen. There are usually 1 or 2 of these pedicellariae between any 2 inferomarginal spines. All the plates, spines, and pedicellariae are covered by a rather thin, soft skin, which hides the outlines of the plates. Between the inferomarginal and adambulacral spines is an area of bare membrane crossed by shallow creases or furrows opposite the interspaces between the spines.

Adambulacral plates, small, wider than long, slightly constricted or excavated along each transverse margin, and when they are cleaned, a distinct notch is visible on the furrow margin. On the proximal half of the ray there are 10 plates opposite 4.5 inferomarginals, and beyond the middle of the ray 10 plates correspond to about 5 inferomarginals. Each plate bears a single lanceolate, obtusely pointed, slightly flattened spine 1.5 to 1.75 mm. long on the furrow margin except the first 5 or 6 plates, which carry each a second subequal spine on the outer half of the plate. Irregularly scattered along the furrow are 5 to 8 unguiculate pedicellariae, with 3 curved tines. (Pl. 155, fig. 3*b*.)

Wedged in between the interradial pair of unarmed inferomarginals and the mouth plates are 2 or 3 small actinal intermediate plates, wholly obscured by skin.

The oral plates are narrow and form a projection toward the mouth, impinging upon the furrow in such a way as to lessen its diameter at its junction with the actinostome about one-half. The plates bear each 3 stout, tapering, bluntly pointed spines, one on the actinostomial face, and directed toward its fellow of the opposite side of the mouth of furrow, while the other 2 are more robust and are on the actinal face of the plate. Two cat-claw pedicellariae are on the furrow face of the plates.

Madreporic body small, somewhat prominent, with a few fine radiating irregular striae and coarse intervening ridges. It is situated at about the middle of r and has 7 conical spines, like those of the rest of dorsum, in a half circle on its adcentral side. Tube feet in 2 series.

Type.—Cat. No. 37031, U.S.N.M.

Type-locality.—Station 5664, Macassar Strait (lat. 4° 43′ 22″ S.; long. 118° 53′ 18″ E.), 400 fathoms, hard bottom, bottom temperature 43.3 F.; 1 specimen.

Remarks.—The known species most nearly related to the one here described is *Tarsaster stoichodes* Sladen, taken by the *Challenger* at station 219, off D'Entrecasteaux Reef, north of the Admiralty Islands (lat. 1° 54′ S.; long. 146° 39′ 40″ E.), in 150 fathoms, on coral mud. There is some doubt as to the generic identity of the present species on account of its biserial tube feet. The specimen is small, and larger individuals may have the feet in 4 series, just as happens with *Coronas-*

ter and other forms. If it has permanently the biserial arrangement it will form a connecting link with the Pedicellasteridae, which have very few characters, other than the biserial tube feet, that can not be duplicated among the Asteriidae. The type of *Hydrasterias*, *H. ophidion* Sladen, is figured as having biserial tube feet, however.

Family PEDICELLASTERIDAE Perrier.

Subfamily LABIDIASTERINAE Verrill.[1]

In Verrill's scheme of classification this subfamily is placed in the Brisingidae, following the usual treatment of *Labidiaster*. I would suggest however, that *Labidiaster* has few essential characters in common with the Brisingidae, but rather exhibits greater structural similarity to *Coronaster*. This genus seems to be more nearly allied to *Pedicellaster* than to either *Heliaster* or to any of the recently proposed genera of Asteriidae. I would therefore place *Labidiaster* in the Pedicellasteridae. I have dissected a large example of *Labidiaster radiosus* Lütken, from the Straits of Magellan.

Labidiaster differs from *Brisinga*, *Odinia*, *Freyella*, and similar genera in the following important particulars: (1) Its abactinal skeleton is not duplicated in the Brisingidae; (2) forficiform, or straight, pedicellariae are present; (3) the adambulacral plates are crowded, very short in proportion to width, and entirely unlike in form and armature the same highly peculiar plates of all Brisingidae; (4) the ambulacralia are shorter, especially the dorsal ends, which overlap, or imbricate with, the next adoral ambulacral plate, while in the Brisingidae there is no sign of imbrication, the ambulacralia resembling the centra of chordate vertebrae, with vertical articulating adoral and aboral facets.

In the Brisingidae (in the narrower sense) the abactinal skeleton of the rays is variable, being in the form of transverse, independent, parallel ridges or costae, separated by areas of integument without plates; or the intervals may be partially or completely filled in with more or less imperfectly developed plates immersed in the body-wall; or the arches may be absent and a tessellation of thin plates may cover the genital region of the ray; or there may be thin plates, more or less spiniferous, together with differentiated transverse costae.

In *Labidiaster* the skeleton of the ray is closely similar to that of *Coronaster*. There is a longitudinal series of trilobate inferomarginal plates, one of quadrilobate or cruciform superomarginal plates, and one of cruciform median radial plates. The marginals and radials form regular transverse series. On the basal portion of the ray there is a more or less irregular zigzag series of trilobate dorsolateral plates. The primary plates either connect directly by their slender lobes, or these are joined by one or two overlapping, oblong, intermediate ossicles. There results an open, fairly regular, reticulate skeleton having large tetragonal meshes (except where the dorsolateral plates frame pentagonal openings). On the outer part of the ray the *longitudinal*, intermediate, connecting plates and the longitudinally oriented lobes of the marginals and radials gradually disappear, so that there remains only a series of independent, transverse, slender skeletal bands, simulating those of *Brisinga*, but having a very different history.[1] The skeletal meshes contain numerous papulae. The form and armature of the adambulacral plates are as in *Coronaster*. The arrangement of the pedicellariae either on retractile wreaths surrounding the spines or on retractile transverse cushions is not unlike that found in *Coronaster*. The mouth plates of the Brisingidae, of *Coronaster*, *Pedicellaster*, and of *Labidiaster* are similar in general form, those of *Labidiaster* being relatively the smallest.

---

[1] Verrill 1914*a*, p. 26.

The features which are chiefly relied upon to distinguish the Brisingidae, and to which the family in part owes its characteristic appearance, are conspicuous by their different form in *Labidiaster*. Such, in the Brisingidae, are the elongate and peculiarly formed adambulacral plates; the long needle-like subambulacral and marginal spines, with their characteristic sacculate sheaths; the variable but always non-reticulate abactinal skeleton of the rays; the presence of only crossed or forcipiform pedicellariae.

The genus *Rathbunaster* (type, *Rathbunaster californicus*, from off California, deep water) was described by me as a neighbor of the curious polybrachiate *Pycnopodia* of Stimpson. I think the genus is related, instead, to *Coronaster*. It is notable for the suppression of the alternate superomarginal plates and the reduction of the abactinal skeleton to spaced circular plates without trace of connectives. The marginal and abactinal plates bear an acicular spine surrounded by a retractile sheath with an expanded distal crown covered with numerous pedicellariae. The ambulacral, adambulacral, and oral plates are similar to those of *Coronaster*.

In *Labidiaster*, *Coronaster*, *Rathbunaster*, and certain genera of the Brisingidae there are two gonads to each ray; each gonad opens upon the side of the ray at some distance from the base. All three genera, as well as the Brisingidae, have a single ampulla to each tube foot.

---

[1] Verrill, in his "Monograph of the Shallow-water Starfishes of the North Pacific Coast," 1914, p. 352, proposes a new genus, *Labidastrella*, for *Labidiaster annulatus*, Sladen. "It differs considerably in structure from *L. radiosus*, especially in having the dorsal and superomarginal plates nearly abortive distally, on the rays, beyond the genital regions." It is evident that this tendency to lose the dorsal skeleton of the distal part of the ray manifests itself in *L. radiosus*, and is carried further in *L. annulatus*. I agree with Koehler that it does not form a safe basis for a generic division between two otherwise similar species (Koehler, Ann. de l'institut océanographique, vol. 7, fasc. 8, May 1917, p. 8).

The family Pedicellasteridae, if these views are correct, would consist of the subfamily Pedicellasterinae with *Pedicellaster*, *Lytaster*, and *Gastraster*, and of the Labidiasterinae with *Labidiaster*, *Coronaster*, and *Rathbunaster*.

Genus CORONASTER Perrier.

Coronaster PERRIER, Ann. sci. nat., art. 8, 1885, p. 13. Type, *C. parfaiti* Perrier, 1894, p. 92, pl. 8.—VERRILL, 1915, p. 31.—FISHER, 1917*a*, p. 26.

Stolasterias (subgenus) part SLADEN, 1889, p. 584.

Heterasterias VERRILL, 1914*a*, p. 46. Type, *Asterias* (*Stolasterias*) *volsellata* Sladen.

The generic term as here used is in an extended sense, including Sladen's *Asterias volsellata* and hence the genus *Heterasterias* Verrill, founded upon that species.

Coronaster, as formerly understood, comprised the following nominal species: *C. parfaiti* Perrier, the type, from the Cape Verde Islands; *C. antonii* Perrier, a very immature specimen from Morocco; *C. briareus* (Verrill), from off the southern Atlantic coast of the United States; *C. bispinosus* Ives, locality unknown, perhaps identical with *briareus; C. octoradiatus* (Studer), from South Georgia Island.

I have compared a specimen of *Coronaster briareus* from 90 fathoms, Gulf stream, south of Key West, with the examples of *C. volsellatus* (=*Asterias volsellata*) listed in this report. In my specimen of *briareus* the tube feet are crowded and quadriserial, or arranged in what one might prefer to call two crowded zigzag series, inasmuch as the pores remain biserial, or nearly so. Professor Verrill (1915, p. 31), in the most recent diagnosis of *Coronaster*, writes that the tube feet are biserial (as, indeed, they are in the small type and in small specimens of *briareus*). This character is determined by age. Even in the very small *C. antonii*, as mentioned by Perrier (1894, p. 96, pl. 8, fig. 2*c*), the pedicels are incipiently quadriserial on a part of the ray. In full-sized specimens of *C. volsellatus* the tube feet are quadriserial, or biserial at the tip and base and quadriserial throughout the greater part of the ray. In small regenerating rays of *volsellatus* the pedicels are biserial, and these small rays correspond exactly to the rays of immature specimens of other species.

Furthermore, the highly characteristic skeleton of *volsellatus* is nearly exactly duplicated, with minor specific differences, by that of *briareus*. This skeleton, which holds good also for *C. parfaiti* and *C. antonii*, as figured by Perrier (1894, pl. 8), consists of slender-lobed plates, joined by more or less elongate connecting ossicles in such a way as to form a median radial, and two marginal regular longitudinal series, joined together at the intervals of the primary plates by transverse ossicles, leaving four series of large, rectangular papular areas. At each node of this skeletal mesh is a sharp spine with a retractile wreath of abundant pedicellariae. The inferomarginal plates abut closely against the adambulacrals. Both species have the curious hand-shaped unguiculate major pedicellariae of conspicuous size, characteristic of the genus very probably.

Perrier (1894, pl. 8) has given carefully drawn figures of *C. parfaiti* and *C. antonii.* The skeleton is the same as that of *briareus* and of *volsellatus.* It seems reasonable, on account of the small size of Perrier's specimens, to consider them immature. They match very well the immature regenerating rays of *volsellatus*, which, as noted above, also have the pedicels biserially arranged.

Coronaster volsellatus has one adambulacral spine, the other species generally 2. In *C. parfaiti* there are 3 spines on the first 5 plates and 2 on the others. *C. antonii* has the spines "solitary on the majority of the plates, but in pairs on certain others among them." I do not think the monacanthid condition of *volsellatus* of sufficient importance to warrant a generic separation. The new Philippine and Moluccan species, *C. halicepus* is diplacanthid and is apparently a close relative of *volsellatus.*

Coronaster is therefore represented in the East Indies by 2 species, and in the Atlantic by 5 nominal forms.

The family affiliations of *Coronaster* are somewhat involved. Its only strong Asteriid character is the quadriserial arrangement of the tube feet. Yet the ambulacral plates are not crowded, the pedicel pores being nearly or quite biserial as in the Brisingidae, to which family its strongly brisingoid mouth plates, as prominent as those of *Odinia*, would also ally it. Its skeleton is more like that of a simplified *Pedicellaster* than like that of *Asterias*, or allied genera. *Pedicellaster* has mouth plates of the same sort as *Coronaster.* They are more prominently "adambulacral" than those of any genus of the Asteriidae, even of *Coscinasterias*, and are nearly or quite as prominent, relatively, as the oral angles in *Brisinga.* So also in *Pedicellaster* the ambulacral plates are uncrowded, as in *Coronaster*, rather brisingoid, and the pedicel pores are in 2 series. As noted above the pedicel pores in large specimens of *Coronaster* form 2 slightly zigzag rows, but much less pronounced than in small specimens of *Coscinasterias* (in the broadest sense), in which group the ambulacrals are quite compressed and crowded.

On the whole the relationship of *Coronaster* does not appear to be so close to the Asteriidae as to the Pedicellasteridae, even though one of its species long occupied an undisputed corner in the former family.

KEY TO THE SPECIES OF CORONASTER HEREIN DESCRIBED.

a^1 Rays 11; 1 adambulacral spine; adambulacral furrow pedicellariae slender, the tips of jaws not conspicuously crossed; abactinal forcipiform pedicellariae with 5 or 6 lateral teeth in one row; the large major unguiculate pedicellariae with proximal half abruptly narrowed____*volsellatus*, p. 496.

a^2 Rays 10; 2 adambulacral spines; adambulacral furrow pedicellariae fairly stout, the tips of jaws conspicuously crossed; abactinal forcipiform pedicellariae with 12 or more lateral teeth in 2 series proximally; proximal third of major unguiculate pedicellariae narrowed____________*halicepus*, p. 497.

CORONASTER VOLSELLATUS (Sladen).

Plate 135, figs. 4, 4*a*; plate 151, figs. 2, 2*a–c*.

Asterias (Stolasterias) volsellata Sladen, 1889, p. 584, pl. 107, figs. 1–4.
Heterasterias volsellata Verrill, 1914*a*, pp. 27, 47.
Coronaster volsellatus Fisher, 1917*a*, p. 25.

This species has been fully described and figured by Sladen in the *Challenger* report. The specimens collected by the *Albatross* agree in all essential particulars with the type. I have figured the pedicellariae as they differ from those of *halicepus*, described below. The small pedicellariae arming the sheaths of the abactinal and marginal spines are smaller than those of *halicepus*, averaging about 0.45 mm. in length. In addition to 2 terminal teeth each jaw has usually 5 small teeth in a single series along the inner side. The forficiform pedicellariae from the ambulacral furrow are about 1.25 mm. long, and are quite slender, the tips of the jaws not crossing conspicuously. Similar but smaller pedicellariae occur scattered over the integument among the papulae, and on the trabecular ridges of the skeleton. The unguiculate major pedicellariae are longer than those of *halicepus*, and are narrowed into a longer proximal portion, forming a sort of wrist to the miniature hand.

Type.—In the British Museum (Natural History).

Type-locality.—Near Cebu, Philippine Islands, 95 fathoms.

Distribution.—Philippine Islands, 95 to 165 fathoms, on sand.

Specimens examined.—Four, from the following Philippine stations:

Section 5226, 9.5 miles southwest Corregidor Light, Luzon, no depth or bottom recorded; 1 specimen.

Station 5391, between Samar and Masbate, 118 fathoms; 1 specimen.

Station 5393, between Samar and Masbate, 136 fathoms, hard sand, 1 specimen.

Station 5417, between Cebu and Bohol, 165 fathoms, gray mud, sand, bottom temperature 54.4° F.; 1 specimen, incomplete.

Remarks.—The stomach of a specimen from station 5391 contained portions of several small shrimps and a small fish. The very numerous pedicellariae are capable of holding fairly active animals and are probably used to capture prey. The loose skeleton renders the rays very flexible, so that any crustaceans or fish held fast by the pedicellariae could be readily reached by the tube feet and conveyed to the mouth.

CORONASTER HALICEPUS Fisher.

Plate 135, figs. 5, 5*a*; plate 140; plate 151, figs. 1, 1*a–d*.

Coronaster halicepus FISHER, 1917*a*, p. 26.

Diagnosis.—In general appearance closely resembling *C. volsellatus*, but differing in having 10 rays, 2 adambulacral spines, relatively broader and shorter unguiculate pedicellariae, with longer claws, heavier ambulacral pedicellariae, with the jaws conspicuously crossed at tips, and longer forcipiform minor pedicellariae, each jaw with upward of 12 or even more small teeth in addition to the large terminal teeth (5 or 6 in *volsellatus*). R=260 mm., r=17 mm., R=15±r; breadth of ray at base, 11 mm.; at 25 mm. from base, 14 or 15 mm.; height of disk, 10 mm.; breadth of disk, 34 mm.; breadth of actinostome, 20 mm.

Description.—Skeleton similar to that of *volsellatus*, there being abactinally 3 lines of ossicles extending the length of the ray (the carinal and superomarginal), and adjacent to the adambulacrals an inferomarginal series. Equally narrow transverse bands of plates divide the integument into quadrate papular areas of large size, the intermarginal areas being regular, wider than long proximally, and longer than wide distally. The areas between the carinal and superomarginal plates are longer than the foregoing, and irregular as to the transverse trabeculae. The cruciform primary plates at each node are connected by 1 or 2 intermediate oblong ossicles and bear a single slender acicular spine, the inferomarginal the longest, equaling proximally the distance between the base of the inferomarginal and corresponding superomarginal spines (7 mm). The superomarginal spines are one-half to two-thirds as long, and the carinal spines are subequal to the superomarginal, though a trifle more robust. In large specimens 2 or 3 small spines stand on the transverse irregular trabecula between the superomarginal and carinal plates.

Each spine is surrounded by a heavy, retractile, globular sheath covered with small forcipiform pedicellariae, about 0.5 to 0.6 mm. long, whose jaws have 3 terminal teeth and a double row of upward of 12 small teeth, while similar pedicellariae in *volsellatus* have 2 terminal and about 5 lateral teeth. The difference is best seen from the figures. The trabeculae and papular areas have numerous large 6-clawed unguiculate pedicellariae about 1.5 mm. long. These are much more numerous than in *volsellatus* and are shorter and broader.

In addition, there are numerous small forficiform pedicellariae scattered among the papulae. The papulae occur in tufts or clumps, about 6 or 7 to each area.

Adambulacral plates small and bandlike, separated by an interval slightly in excess of their length. Spines, 2, slender, slightly tapered, blunt, situated on the furrow margin in an oblique series, the inner being aboral to the outer and about two-thirds to three-fourths as long; the latter is one-half to three-fifths as long as the inferomarginal spine. About every other plate has on the furrow face 1 or 2 forficiform pedicellariae about 1 to 1.25 mm. long. These extend between the tube feet, and are at the end of a thick, apparently highly extensible stalk or peduncle, around the base of which are 1 to several very small pedicellariae. These pedicellariae have the ends of the jaws crossed and are broader than in *volsellatus*, where the jaw tips fit together snugly. In the small regenerating rays of a specimen from station 5217 (the tube feet being 2-ranked) the adambulacral plates have 2 truncate, slightly tapered, subequal spines.

Mouth plates resembling those of the Brisingidae, excavated on the furrow margin for the first tube foot. On the middle of the actinal surface of each plate is a robust, flattened, truncate spine about as long as the median suture. On the actinostomial margin are 2 similar shorter spines, 1 directed across mouth of furrow, the other midway to the median suture. From the base of the latter is a short flap of membrane, and from the former are 2 long, slender sacculi crowded with very numerous small pedicellariae. Two large pedunculate, unguiculate pedicellariae (similar to those of the abactinal surface) extend over the actinostome from between the inner marginal spines of each mouth-pair. Numerous small forficiform pedicellariae with short, thick pedicels are scattered over the surface of the plates, and sometimes 1 or 2 major unguiculate pedicellariae in addition. In *volsellata* there are the same number of spines, but the marginal spines lack the streamers of pedicellariae. The unguiculate pedicellariae are present, but very few small pedicellariae on the surface of the plate. In the type the first 10 pairs of tube feet are obviously 2-ranked; then they become crowded and 4-ranked, returning to 2 series on the outer attenuate part of the ray. A smaller specimen from station 5217 has the feet less obviously 4-ranked. It is wholly a matter of age.

In *haliceps* the disk has more numerous spines—about 30—and more numerous unguiculate pedicellariae. The madreporic body is slightly larger.

Type.—Cat. No. 37012, U.S.N.M.

Type-locality.—Station 5281, between Lubang and Luzon, 201 fathoms, dark gray sand, bottom temperature 50.4° F.; 1 specimen.

Distribution.—Philippine and Molucca Islands, 105 to 298 fathoms, on sand.

Specimens examined.—In addition to the type, 1 specimen, and fragments from the following stations:

Station 5217, between Burias and Luzon, 105 fathoms, coarse gray sand, 1 specimen.

Station 5417, between Cebu and Bohol, 165 fathoms, gray mud, sand, bottom temperature 54.4° F.; 4 rays.

Station 5621, Molucca Islands, off Molucca Passage, 298 fathoms, gray and black sand; 4 rays.

Subfamily PEDICELLASTERINAE Fisher.[1]

Genus PEDICELLASTER Sars.

Pedicellaster Sars, Oversigt af Norges Echinodermer, 1861, p. 77. Type, *P. typicus* Sars.

PEDICELLASTER CHIROPHORUS Fisher.

Plate 142, fig. 2; plate 155, figs. 2, 2*a*–b.

Pedicellaster chirophorus 1917*b*, p. 93.

Diagnosis.—Rays 5. R=27 mm., r=4 mm., R=7 r±; breadth of ray at base, 4.5 mm. Rays slender, tapering, disk small; plates cruciform, in regular series, each bearing a short thorny spinelet and 1 to 3 ovoid forcipiform pedicellariae. Adambulacral armature: a transverse row of 3, then 2, spinelets 2 to 3 times longer than those of the adjacent actinal and marginal plates, and here and there along the ray a large unguiculate pedicellaria usually borne on or near the furrow margin; 5 oral spinelets.

Description.—Plates of ray 4-lobed or 3-lobed and arranged in longitudinal and less regular transverse series. There is a midradial or carinal series, a superomarginal, inferomarginal, and 2 actinal intermediate series. Between the carinal and superomarginal series, which are regular, is a zigzag series of dorsolateral plates, or what might equally well be considered 2 series of 3-lobed plates alternating in position, with reference to the plates of the neighboring series. At the base of the ray an elliptical secondary plate is interpolated (usually) between the alternate adradial plates and the carinals and between the other dorsolaterals and the superomarginals. A similar plate connects the proximal superomarginals with the corresponding inferomarginals. On the disk there are 2 or 3 plates of a third actinal intermediate series adjacent to the adambulacral plates. The first intermediate series reaches about half the length of ray, the second a little less than one-third. The inferomarginals are therefore contiguous to the adambulacrals on the outer half of the ray. The plates each bear a short, somewhat four-sided, only slightly tapered, spinelet, superficially truncate, but really terminating in 3 or 4 minute sharp prongs, with sometimes accessory points below them. These spinelets are 0.4 to 0.6 mm. in length and 0.15 to 0.18 mm. thick just above the base. These spinelets are borne on a slight rounded eminence at the middle of the plate. A few abactinal plates have a smaller accessory spinule on one of the lobes. Each plate bears also 1 to 4 forcipiform, ovoid pedicellariae, usually on the margin of the papular areas, and about 0.36 to 0.38 mm. in length. These have the appearance in the dry specimen of being pretty uniformly scattered over the surface of the body.

---

[1] Fisher, 1918, p. 108.

There are 8 longitudinal rows of somewhat quadrate papular areas, which usually contain a single papula. In addition between the first and second actinal intermediate series of plates is a very short series of narrow subtriangular papular areas.

The terminal plate is large and subcircular except on the side toward the ray, where there is an obtuse angular notch or indentation. The plate is covered with spinelets 2 or 3 times as long as those of the adjacent abactinal and marginal plates.

Adambulacral armature, a regular transverse series of 3 slender, tapering pointed, slightly thorny spinlets, the median a trifle the largest, borne on a moderately developed ridge of the plate. On the outer two-thirds of the ray there are only 2 such spines. About 6 or 8 plates along either side of each furrow, and irregularly spaced, bear on the inner edge, near the furrow spine, a relatively huge unguiculate forficiform pedicellaria, with usually three curved claws or teeth. These are 1 to 1.2 mm. long and resemble 2 minute clasped hands (with 3 short fingers). On 2 rays there is a large pedicellaria on the outer side of the third plate. Most of the adambulacral plates have also an ordinary forcipiform pedicellaria just external to the outermost spine.

Mouth plates fairly prominent and with a prominent median suture. The form of the combined pair is a truncated oval, the suboral surface being narrower toward the inner than at the outer end. Armature: a single series of tapered spinules, there being usually 3 larger ones on the actinal surface and 2 conspicuously smaller ones, one above the other, on the actinostomial face of the plate. One plate has a large cat-claw pedicellaria on the outer, furrow corner.

Tube feet strictly biserial. Madreporic body flat, with radiating coarse striae. It is situated about midway along the minor radius.

Type.—Cat. No. 37030, U.S.N.M.

Type-locality.—Station 5656, Gulf of Boni, Celebes (lat. 3° 17′ 40″ S.; long. 120° 36′ 45″ E.), 484 fathoms, gray mud, bottom temperature 41.2° F.; 1 specimen.

Remarks.—This species differs from all others of the genus in having relatively enormous unguiculate adambulacral pedicellariae in combination with proximally 3 adambulacral spines. *Pedicellaster atratus* Alcock, from the Andaman Sea and Bay of Bengal, 220 to 290 fathoms, is of very large size for this genus, has 2 adambulacral spines only, and lacks the large cat-claw pedicellariae. Its color is described as uniform jet-black.

PEDICELLASTER, species.

There is a mutilated specimen of a *Pedicellaster* differing from the preceding in having 2 adambulacral spines throughout the ray, in lacking large forficiform cat-claw pedicellariae, in having rather fewer minor pedicellariae (which, however, are closely similar to those of *chirophorus*). The spinelets are enveloped in a very evident sacculus.

Station 5630, south of Patiente Strait (lat. 0° 56′ 30″ S.; long. 128° 05′ E.), 569 fathoms, coral sand, mud.

Family BRISINGIDAE G. O. Sars.

SYNOPSIS OF THE KNOWN GENERA OF BRISINGIDAE.[1]

a^1. Abactinal surface of disk and genital region of ray provided with numerous conspicuous papulae; 2 gonads to each ray; mouth plates broad and fan-shaped toward the actinostome, nearly closing the entrance to the ambulacral furrow; genital region of ray with transverse skeletal arches, between which the integument is strengthened by immersed plates and pierced by papular pores; ray with regularly spaced, lateral, transverse combs of upward of 7 conspicuous, slender spines; adambulacral plates higher than long, with a single, prominent subambulacral spine, frequently truncate and more or less spatulate proximally; first 3 to 5 pairs of adambulacral plates united in each interradius, and above them the marginal plates are similarly united; a syzygy between first and second adambulacral plates, and also sometimes a partial syzygy between the second and third and between the third and fourth plates. Genotype, *Brisinga semicoronata* Perrier____________________________*Odinia* Perrier.

a^2. A single circle of rather small papulae near margin of disk, 2 papulae corresponding to each ray; rays, as in *Brisinga*, without papulae. First and second adambulacral plates united by a syzygy (nonmuscular symphysis) and upper part of second and third ambulacral plates united by syzygy; gonads numerous, in series; first pair of adambulacral plates in each interbrachium closely united (as in figs. 2 and 2*a*; pl. 156). Genotype, *Brisinga mimica* Fisher_______________________________*Brisingenes* Fisher.

a^3. No papulae present either on disk or on rays.

b^1. No visible abactinal skeleton on rays but embryonic plates may be concealed in the thin integument; gonads unknown.

c^1. Minute embryonic lattice-plates are present in abactinal integument of rays; functional skeleton of ray reduced to ambulacral and adambulacral plates; disk finely spinulate, a few spinelets extending upon ray; interbrachial skeleton resembling that of *Brisingella*, but the first marginals unequal in size; first adambulacral plates entirely separated; adambulacral armature very simple. Genotype, *Hymenodiscus agassizi* Perrier______________________*Hymenodiscus* Perrier.[1]

---

[1] For *Labidiaster,* see under Pedicellasteridae.

c^2 Rays composed of ambulacral and adambulacral plates and an abactinal integument devoid of skeleton, but covered with numerous, relatively large pedicellariae arranged in transverse bands. Disk not known. Genotype, *Gymnobrisinga sarsii* Studer_______*Gymnobrisinga* Studer.

b^2. Abactinal skeleton present on disk, and on proximal portion of rays at least, either in the form of transverse independent skeletal arches or as a continuous covering of thin plates, or both arches and intervening thin plates.

c^1. Disk plates large, with a comparatively few, fairly large, disk spines, and a vertical series of about 4 conspicuous, lateral spines to each successive skeletal arch of the rays, these lateral combs occurring at regular intervals all along side of ray; mouth plates expanded fanwise toward actinostome, nearly closing entrance to ambulacral furrow; subambulacral spine with a modified truncate tip; first pair of adambulacral plates of each interbrachial angle united, but the united pair of conspicuous first marginal plates is interpolated from above between their distal ends; syzygy (?); related to *Odinia*. Genotype, *Brisingaster robillardi* de Loriol____*Brisingaster* de Loriol.

c^2. Disk plates small, bearing 1 to several small spinelets; on the ray only 1 lateral or marginal spine corresponding to the variably spaced inferomarginal plates; never a vertical comb of conspicuous lateral spines.

d^1 First and second adambulacral plates as well as the upper part of the second and third ambulacral plates united by syzygy (nonmuscular symphysis).

---

[1] For description see Perrier, 1884, p. 189, pls. 1 and 2. The type of *Hymenodiscus agassizi* (No. 1448, Museum Comparative Zoölogy) is almost certainly a very immature specimen, as it is small, and there are no gonads. There are no skeletal arches on the rays and the greater part of the thin abactinal integument has been removed. The fine spinulation of the disk extends upon the base of the ray. The abactinal integument of the ray, although very delicate, contains a single layer of latticework holothuroid plates, some of which at the very base of the ray bear minute spinelets. From this it would seem that the abactinal wall of the ray is destined to be similar to that of *Freyella*, unless in the fully adult animals the plates retain their embryonic character.

The interbrachium resembles that of *Brisingella*, but differs in having the first marginals (those which bound the apex of the interbrachial angle) unequal in size. (See Fisher 1918, p. 104, figs. 1 and 2.) In *Brisingella* these plates are equal, and the suture between the interradial ends is on a line with the interradial, or median oral, suture. There is a distinct syzygy between the first and second adambulacral plates. The interbrachia are not so open as in *Brisingella*, as the inner ends of the first adambulacral plates are normally in contact, or very nearly so. In an adult specimen we would expect to find these plates still closer together. It is worth noting that in *Freyellaster* and in *Brisinga*, s. s., the first marginal plates are of unequal size. (See pl. 156, figs. 1 and 1*a*.) Yet in its present juvenile form the interbrachial angle is different from that of either *Freyellaster* or *Brisinga*, while the entire absence of costal arches, as well as of gonads, may reasonably be attributed to immaturity. It does not seem possible to identify this problematical form with any other genus, except the even less known *Gymnobrisinga* of Studer.

Gymnobrisinga sarsii (Abhandl. Akad. Wiss. Berlin, Anhang, Abth. 2, 1884, p. 13, pl. 3, fig. 5) is based upon a brisingoid ray only. This lacks a dorsal skeleton, and while the large pedicellaria figured by Studer is different from those of *Hymenodiscus agassizi*, I am quite unprepared to offer an opinion as to the generic distinctness of the two species.

e^1. Abactinal skeleton of rays in the form of independent spaced arches or costae composed of elongate, more or less compressed, overlapping plates, projecting well above the level of the intervening integument and bearing small spinelets; intercostal integument not fortified by thin, immersed, spineless fenestrated plates.

f^1. Gonads numerous, in a series along either side of each ray; the interradial (first) pair of adambulacral plates is joined by their lateral faces, and above them is a united pair of first marginal plates—four in all. (Figs. 1 and 1*a*, pl. 156.)

g^1. Subambulacral spines of proximal adambulacral plates slender, acicular; the accessory subambulacral spine, if present, is on the adoral half of the plate; adambulacral armature is not dense and crowded. Genotype, *Brisinga endecacnemos* Asbjørnsen__________________________*Brisinga* Asbjørnsen.

g^2. Subambulacral spines of proximal adambulacral plates with modified, capitate, often truncate, tips; second subambulacral spine regularly present, prominent, and near aboral end of plate; adambulacral plates short, with crowded armature. Genotype, *Brisinga panopla* Fisher.
Craterobrisinga Fisher.

f^2. Gonads 2 to each ray (one on each side); subambulacral spines all delicate and acicular.

g^1. The interradial (first) pair of adambulacral plates is joined by their lateral faces, and above them is a united pair of first marginal plates—4 in all. (Figs. 2 and 2*a*, pl. 156.) Genotype, *Brisinga moluccana* Fisher______*Astrostephane* Fisher.

g^2. The interradial (first) pair of adambulacral plates is not joined, but separate, the outer end of the combined mouth plates being usually interpolated between the inner ends of these adambulacral plates; first pair of marginal plates is not closely united by their lateral faces but only by the adoral ends, to which also is closely united the lower end of the interradial plate, forming a rude reversed Y, of which the angle is the apex of the interbrachial angle and the arms are the first marginal plates (figs. 3 and 3*a*, pl. 156); adambulacral plates slender, with delicate subambulacral spine; rays delicate, very deciduous. Genotype, *Brisinga fragilis* Fisher.
Brisingella Fisher.

e^2. Abactinal skeleton of rays consisting of independent compressed arches or costae as in *Brisinga*, but the integument between the arches is crowded with numerous, spineless, immersed, fenestrated, thin plates, sometimes slightly overlapping, yet leaving the integument quite flexible; gonads 2 or 4 to each ray.

f^1. First pair of adambulacral plates united, and joined to their upper side is a united pair of marginal plates, 4 in all, as in *Brisinga;* proximal adambulacral plates higher than long; gonads 2 to each ray. Genotype, *Brisinga* (*Stegnobrisinga*) *placoderma* Fisher_____________________*Stegnobrisinga* Fisher.

f^2. First pair of adambulacral plates not joined together by their lateral faces, but separate; first pair of marginal plates is not closely united by their lateral faces, but only by the adoral ends, to which also is closely united the lower end of the interradial plate, forming a rude inverted Y, of which the angle is the apex of the interbrachial angle and the arms are the first marginal plates (figs. 3 and 3*a*, pl. 156); proximal adambulacral plates not higher than long; gonads 2 or 4 to each ray. Genotype, *Brisinga panamensis* Ludwig._*Astrolirus* Fisher.[1]

e^3. Abactinal skeleton of genital region of ray composed of a uniform armor of thin spiniferous, more or less overlapping plates, but not of independent arches or costae.

f^1. Primary plates of disk much larger than the others which are small; gonads 2 to each ray; an interradial plate, vertical in position, is interpolated between the proximal ends of the first adambulacral plates, and touches the mouth plates, but does not encroach upon the actinal surface as in *Colpaster*. Genotype, *Belgicella racovitzana* Ludwig____________*Belgicella* Ludwig.

f^2. Primary plates of disk not conspicuous, and not distinguishable from the other abactinal plates of disk.

g^1. An azygous interradial plate, shield-shaped and conspicuous superficially on the actinal surface, separates the first pair of free adambulacral plates; gonads unknown. Genotype, *Colpaster scutigerulus* Sladen_____________*Colpaster* Sladen.

g^2. First pair of adambulacral plates not separated by an azygous plate, but united as in *Brisinga*, and above them is a pair of conspicuous, united, first marginal plates—4 in all in each interradial angle; gonads numerous, in a series along either side of the ray. Genotype, *Freyella fecunda* Fisher.
Freyellaster Fisher.

d^2. No syzygy, or nonmuscular symphysis, between the first and second adambulacral plates nor between the upper part of the second and third ambulacral plates, but a normal muscular symphysis not different from the others; no marginal plates directly above the first pair of adambulacral plates; the latter are usually not united except sometimes by the proximal ends; touching the lower end of the interradial plate is a pair of very inconspicuous plates lying in the same plane, and superficially appearing to be a part of the interradial plate.[2] These are really the outer ends of the mouth plates which project dorsally behind the first pair of adambulacral plates. The latter, by sometimes touching at their inner ends or apposing their lateral faces, segregate this dorsal portion of the mouth plates from the actinal, spine-bearing part. For this reason they may easily be mistaken for 2 entirely independent plates (see fig. 4, pl. 156).

e^1. Abactinal skeleton of ray composed of a uniform armor of thin, spiniferous more or less overlapping plates as in *Freyellaster*, not of spaced, independent arches or costae; furrow spinelets not modified or expanded at the tip. Genotype, *Freyella spinosa* Perrier____*Freyella* Perrier.

e^2. Abactinal skeleton of ray composed of independent transverse arches, composed, on radial area, of flattened, overlapping plates (not of elongate, narrow, more or less compressed ossicles as in *Brisinga*); these costae bear spinelets and are separated by intervals devoid of plates; furrow spinelets with curiously modified expanded tips. Genotype, *Astrocles actinodetus*__*Astrocles* Fisher.[3]

---

[1] Fisher, 1917f, pp. 424, 428.

[2] The interradial plate described by Ludwig in *Belgicella* is very probably the true interradial plate plus these extreme outer ends of the mouth plates, which, unless treated with potash, appear to be a part of the interradial plate (Ludwig, 1903, p. 60).

[3] Fisher, 1917f, pp. 426, 430.

Genus ODINIA Perrier.

Odinia Perrier, Ann. sci. nat., Zool., vol. 19, art. 8, 1885, p. 9. Type, *O. semicoronata* Perrier.

ODINIA PENICHRA Fisher.

Plate 142, fig. 1; plate 151, figs. 3, 3*a–c*.

Odinia penichra Fisher, 1916*b*, p. 31.

Diagnosis.—Rays 16. Rays rather slender, the costal region extending about half the length of ray and containing 10 to 12 complete, rather weak, conspicuously spiniferous costae, widely and nearly equidistantly spaced; disk with steeply beveled margin and conspicuous, terminally denticulate spinelets in ones and twos on its slightly convex plates; adambulacral armature with 1 slender aboral furrow spinelet and 1 actinal spine proximally bifid; oral plates with 4 or 5 actinostomial spinelets, and 1 aboral furrow spinelet; no suboral spine. R=100 mm., r=7.5 mm. (to edge of disk), R=13.3 r; breadth of ray at base, 3.5 mm.; breadth of actinostome, 9 mm.

Description.—Disk with a beveled margin and closely placed, slightly convex, plates bearing usually 1, but sometimes 2 or 3 slender, tapering, spaced spinelets one-half to once their length apart and about 0.75 mm. in length. The tip of the spine consists of several very minute points, and there is usually a tiny pedicellaria at the base. Papulae conspicuous and distributed all over disk.

Rays slender, only slightly inflated at base, and with 10–12 complete, rather weak, widely spaced costae, extending nearly half the length of ray. Beyond these are 3 or 4 rudimentary costae hidden by pedicellariae. The first costa is about one-third the diameter of disk from the base, and the first 6 or 7 intercostal spaces are paved with irregular contiguous plates, becoming disconnected in the 7th and 8th spaces. Scattered plates of the first 2 intercostal areas bear small sharp spinelets. The costae bear spaced, conspicuous, slender spines, usually about 10, of which 3 on each side are much the longest, and the 4 or 5 median are the shortest, except on the first 2 or 3 costae, where the lateral spines are obsolete. The median costal spines of the first 2 or 3 arches are about 2 mm. in length and decrease slightly in length aborad while the lateral 3 spines increase. Of these the outermost is longest and equals the length of about 3.5 consecutive adambulacral plates. The spines are covered with pedicellariae and the papulae extend to the last complete arch, decreasing gradually in number distad. Beyond the eleventh or twelfth costal arch only the 3 lateral spines persist, the median portion of the costa becoming at first rudimentary, these disappearing.

First 10 adambulacral plates a little higher than long, but length and width about equal as seen directly from below. First 3 subambulacral spines tapering and pointed, then compressed, broad and often bifid at tip, the 2 parts being truncate. These spines are about 2–2.5 adambulacral plates in length, and increase very slightly up to the fifteenth, whence they soon lose the truncate tip and decrease gradually in length. At the end of the costal region the subambulacral spine is about three-fourths the length of the adjacent lateral spine. On the aboral apophysis of the plate is a single furrow spinelet about the length of the plate. Beyond the proximal two-thirds of the costal region this is usually lacking.

Mouth plates with an expanded, curved, actinostomial border, a very excavated furrow margin and a less expanded margin adjacent to first adambulacral. No suboral spine. At the outer furrow corner is 1 furrow spinelet about one-third the sutural length of plate. Actinostomial margin with 4 or 5 spinelets (8 to 10 for the combined plates) spread fan-wise toward actinostome and mouth of furrow, where they interdigitate but do not fuse. The lateral spinelets are slightly the longest as a rule. They bear a few pedicellariae.

Gonads are 2 to each ray.

Madrepodic body small and turned toward the margin.

Type.—Cat. No. 37019, U.S.N.M.

Type-locality.—Station 5217, between Burias and Luzon, 105 fathoms, coarse gray sand; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—In general appearance this species resembles *Odinia austini* Koehler and is about the same size as that form, from which it differs in having a more extensive costal region, the first costa being opposite the fifth instead of the fifteenth adambulacral plate; in having on the proximal adambulacral plates an aboral furrow spinelet, and, judging by Koehler's figure (1909, pl. 13, fig. 6), a differently formed oral angle. In *O. penichra* the mouth plates are much larger than in *austini*, the actinostomial margin is broader, the pair of plates are more constricted medially, the spinelets bear pedicellariae, and there is a distal furrow spinelet. According to Koehler's figure the rays are joined together as far as the beginning of the sixth adambulacral plates; in *O. penichra* only the first three are joined. The mouth plates also differ from those of *O. clarki* Koehler (1909, pl. 4, fig. 7) both in form and in lacking a suboral spine. In *O. penichra* the plates are much expanded at the outer as well as the inner end, and there is an aboral furrow spinelet. In neither *clarki* or *austini* is this the case. *O. clarki* differs further in having more numerous costae, more conspicuous costal spines, a greater distance between the disk and the first costal spine, and 1 suboral spine. In *O. pacifica* Fisher, from the Hawaiian Islands, the disk spinelets are cylindrical or swollen at the tip, which ends in many minute points, and there are more often 2 or 3 spinelets to a plate than 1;

there are only 6 or 7 easily recognized costae (only about 5 being conspicuous), confined to the proximal fourth or less of the ray, and the proximal ridges are very indistinct, with a few scattered spines in the median region and none on the sides; there is a short suboral spine, and the marginal oral spinelets are shorter.

ODINIA MAGISTER Fisher.

Plate 143, figs. 1, 2; plate 144, fig. 2; plate 151, fig. 4; plate 152, figs. 3, 3*a* (see also plate 152, fig. 2, *Odinia pacifica*).

Odinia magister FISHER, 1917*b*, p. 93.

Diagnosis.—Differing from *O. pacifica* Fisher in having a perfectly smooth integument on the genital region, in having more numerous, stouter and shorter spines (6 or 7) on the largest lateral fans beyond the genital region, and in having a differently formed articulating surface to the first pair of ambulacral plates of the ray. Disk and number of rays unknown. Ray 350 to 360 mm.; breadth at base, measured at fifth adambulacral plate (the first one which is not joined to its vis-à-vis of the adjacent ray) 10 mm. Size very large; genital region occupying about one-fourth total length of ray, and crossed by about 10 costae, the first 4 or 5 being very irregular and hard to distinguish; lateral spines 5 to 7, 4 and 3 distally; only 1 actinal adambulacral spine, proximally flattened and grooved at tip; pedicellariae all small; none on the integument of genital region; no integumentary prickles or spinelets.

Description.—Ray greatly swollen for about a fourth of its length by the gonads, the highest portion being 25 mm., about 25 mm. from the base. The breadth at this point is 17 to 20 mm. The swollen region tapers from this place into the distal two-thirds of the arm, which is not enlarged. The skin of the genital region is smooth and entirely devoid of prickles or minute spinelets of any sort, and there are no thickly and evenly distributed pedicellariae, such as characterize *O. pacifica.* This skin hides the reticulated skeleton of the basal portion of the ray. For the first 40 mm. of the ray the costal bands of plates are evident superficially only in the mid-dorsal region, where each spaced ridge bears 1 to 3 stout acicular spines about 7 mm. long, incased in a sacculus of pedicellariae. The intervals between the ridges are 5 to 10 mm., differing with the distension of the integument. If a portion of the body wall is treated with caustic potash and dried the plates are seen to be very irregular in shape and diverse in size. The costal plates are elongated, with often 1 or 2 lateral lobes, while the plates which bear the spines are stellate, with 5 or 6 broad, more or less unequal, lobes. The intercostal plates are thin, flat, and overlapping. In the very irregular spaces between them 1 to 5 long vermiform, pointed papulae emerge.

Beyond the first 40 mm. of the ray the costae become well defined and increasingly more prominent, especially on the sides, and bear about 10 spines, spaced all the way across the arm, and longest laterally (10 mm.). Beyond the 80 mm. mark they become more and more localized laterally into fans of sacculated spines borne on a prominent transverse ridge, while the median portion of the ray is devoid both of spines and plates. Proximally there are 6 or 7 spines to a comb (the second and third from the lowest usually the longest, about 12 mm.), then 5 for a considerable distance, then 4, and finally 3 at the end of the ray. (See pl. 143, fig. 2.) As soon as the spines are segregated on lateral combs, pedicellariae in circular cushions appear on the radial area and between the combs, and these pads or flaps sometimes coalesce into incomplete transverse bands. The spines themselves are invested with a thick sacculus, covered with small pedicellariae.

The papulae extend about 110 mm. from base of ray (one-third the total length), and the lateral papulae are often very much swollen at the base, as if distended by products of excretion.

The adambulacral plates are higher than long and bear only 1 large erect spine, which, proximally, is usually flattened and subtruncate at the tip. The terminal portion is not much widened, but there is usually a very evident longitudinal furrow (sometimes 2). The spine then has a couple of incipient truncate or sharp extremities. Beyond the basal third of the ray the extremity of the spine is tapered and either sharp or truncate, and often retains the groove and the 2 more or less well-defined tips. On the outer side of the spine is a thick felting of pedicellariae on a flange of tissue which extends as a flap or pennant beyond the tip of the spine for half or three-quarters its length. The combs of lateral spines are opposite about every third adambulacral plate; there are thus 2 plates interpolated between the plates which have the lateral spines opposite them.

The proximal half of the "genital region" is packed with the gonads which consist of long, slender, mostly dichotomously branched tubules. These converge and open to the exterior 19 mm. from the base of the ray and 12 mm. above the actinal surface of the adambulacral plates. The distal half of the inflated region is filled with the lobulated tubules of the hepatic coeca, which extend nearly half the length of ray. The lobes seem to be solid and are attached to a long axial canal which is scarcely evident above the testes. The lobules when crushed give out numerous oil globules.

Type.—Cat. No. 37026, U.S.N.M.

Type-locality.—Station 5258, off southern Panay (lat. 10° 27′ 45″ N.; long. 122° 12′ 30″ E.): marked intermediate haul in list of dredging stations.

Remarks.—This large species differs from *O. pacifica* in having more numerous, stouter, and shorter spines on the largest lateral fans. In *pacifica* the spines are 4 to a comb, very slender, and the longest equal 7.5 to 8 plates in length while in *magister* there are 6 or 7 spines, 6 to 6.5 plates in length. In *magister* the skin of the genital region is perfectly smooth; in *pacifica* it is thickly peppered with minute pedicellariae. The articulating surface of the first pair of ambulacral ossicles (at base of ray) has, in *magister*, a nearly elliptical contour, but in *pacifica* the upper end is much broader than the lower (see pl. 152, figs. 2 and 3*a*).

Odinia penichra Fisher and *O. clarki* Koehler have a furrow spine; the former has spinelets on the integument between the proximal costal ridges, and scattered pedicellariae, while *clarki* has a long genital region with numerous complete costae, bearing each a complete series of robust conspicuous spines, and has only 4 spines in the lateral fans beyond the genital region.

In *O. austini* Koehler, which is of a delicate habit, like *penichra*, there are no furrow spinelets, but at the very base of the ray there are abactinal spinelets scattered among the papulae, the well spaced 7 or 8 costae are quite distinct, and there are only 3 or 4 lateral spines beyond the costal region.

Genus BRISINGA Asbjornsen.

Brisinga Asbjørnsen, Fauna Litt. Norvegiae, 1856, andet hefte, p. 95. Type, *B. endecacnemos* Asbjørnsen; Fisher, 1917*f*, p. 421, figs. 1 and 2.

Diagnosis.—Brisingidae without papulae; with the abactinal skeleton of rays in the form of transverse independent arches separated by intervals lacking plates (except sometimes microscopic plates carrying minute prickles); with numerous gonads forming a series along either side of each ray; with a syzygy or nonmuscular symphysis between the first and second adambulacral plates, and between the upper end of the second and third adambulacral plates; with a united pair of first adambulacral plates, and first marginal plates in each interbrachial angle—4 plates in all; with the subambulacral spines of proximal plates acicular, unmodified; accessory subambulacral spine, if present, on adoral half of plate.

Remarks.—In *B. trachydisca* Fisher the distal ends of the first or united pair of adambulacral plates of each interradius are wedged apart by the united first marginal plates—or, rather, appear to be. In Sars' admirable monograph of *Brisinga coronata*, two figures of *B. endecacnemos* (Sars, 1875, pl. 8, figs. 8 and 9) show that the first adambulacral plates are not joined so closely as in *Brisingenes*, *Astrostephane*, or *Stegnobrisinga*. But the structure of these interradially situated adambulacrals and marginals is quite different from that of the same plates of *Brisingella*, as may be readily determined by examining plate 4, figures 4 and 6 of the same work. These figures show the structure of the plates on *Brisingella coronata* (G. O. Sars).

B. trachydisca is the only species of the restricted genus *Brisinga* which I have examined.

In the descriptions of the species of *Brisinga* and of related genera a formula has been introduced to denote briefly the adambulacral armature. This is useful for a comparison of the armatures of related forms or for indicating variations within the species. If a transverse line is drawn through the middle of the plate, all the spines aborad of the line are listed as the numerator of a fraction, and all adorad to the line as the denominator. The spinelets within the furrow are each denoted by *i*, the smaller subambulacral spines each by *1*, and the large subambulacral spine, nearly always single, by *I*. Thus if there is an aboral and an adoral furrow spinlet, one adoral subambulacral spine of small size, and the major subambulacral spine is situated exactly in the middle of the plate (it is very often aborad of the middle) the formula would read $\frac{i}{i+1}+I$; or if the large spine is aborad of the middle, $\frac{i+I}{i+1}$. In practice it is sometimes hard to decide whether a small spinelet should be classed as a minor subambulacral, or as a furrow spinelet; that is, whether it should be written *i* or *1*.

BRISINGA TRACHYDISCA Fisher.

Plate 145; plate 149, fig. 5; plate 152, figs. 1, 1*a–c*; plate 156, figs. 1, 1*a*.

Brisinga trachydisca Fisher, 1916*b*, p. 31.

Diagnosis.—Rays 13 or 12; a multicostate form with the spinelets of disk in groups of 2 to 6, spaced like pseudopaxillae; costae 40–45 very prominent, irregular and sinuous, without intercostal bands of pedicellariae, and with relatively coarse spinelets, the costal region occupying more than a third of the total length of ray but less than one-half; adambulacral plates not crowded; armature with 1 aboral furrow spinelet, 1 adoral actinal spine, 1½ to 1¾ the length of the plate, and 1 prominent actinal spine 3 times the length of plate. Rays slender, very long; breadth of disk equals 4 to 4½ times width of ray at base.

Description.—Disk moderate, with rounded margin, the abactinal surface plane and not much elevated above base of rays; spinelets in groups of 2 to 6 on small, spaced, convex plates resembling pseudopaxillae; spinelets slightly tapered, sharp, the tip ending in several minute points, the base sometimes provided with a minute crossed pedicellaria, these scattered also over the intervening integument.

Rays rather slender, but slightly swollen at base. Costae 40–45 occupying more than a third of the total length of ray, but less than one-half. They are irregular, compressed, and very prominent, the sinuous ridge or summit being armed with comparatively coarse, sharp, conical spinelets, their bases flaring, often touching. Sometimes there are two series of them. The costae are frequently incomplete. There are numerous, microscopic pedicellariae on the costae, but no bands of them between the ridges, or at any rate only rudiments, but these bands occur on the outer part of the ray, beyond the region of the ridges. At the base of the ray there are about 6 lateral plates joined, in a series, and the first lateral spine, very slender and sharp, is at about the fifth adambulacral. The succeeding spines occur opposite every other adambulacral, to which the plate is firmly fastened, and are very slender, increasing in length until in the outer part of the costal region they equal in length about 6 adambulacrals.

Adambulacral plates proximally a trifle longer than wide and shallowly excavated toward the furrow. The formula of the armature is $\frac{i+I}{o+1}$ or near the disk $\frac{i}{o+1}+I\cdot$ The aboral furrow spinelet (i) is about as long as the plate measured in the middle of the actinal surface; the large actinal spine (I) is slender and sharp and 3 times the length of the plate, while the adoral actinal spine is $1\frac{1}{2}$ to $1\frac{3}{4}$ the length of the plate. A specimen from station 5494 has a few proximal plates with 2 adoral actinal spines, forming with the large spine an oblique series of 3 $\left(\frac{i+}{o+2}\right)\cdot$ An infrequent variation is 2 aboral furrow spinelets $\left(\frac{ii+I}{o+1}\right)\cdot$ The lateral spines are thickly covered with a sheath of pedicellariae, while the adambulacral spines are somewhat less thickly covered, and tend to be free from them on the side toward furrow.

Mouth plates with a furrow spine extending halfway across mouth of furrow, and another at the aboral end of plate; a small actinostomial spinelet just mesad to the base of the former and two-thirds its length; at the outer end of plate a large suboral, pointed spine 5 times the length of plates, invested with a pedicellaria-covered sacculus which extends half the length of the spine or more beyond the end. Tube feet covered with microscopic lanceolate glands.

Madreporic body small. The articular surface of the pair of ambulacrals of the disk, where a ray has broken off, is much broader above than below, the breadth being about equal to the height, measured from the radial water tube.

Gonads and proximal adambulacral plates as in generic diagnosis.

Type.—Cat. No. 37020, U.S.N.M.

Type-locality.—Station 5491, between Leyte and Mindanao, 736 fathoms, green mud, coral, bottom temperature 52.3° F.; 1 specimen.

Distribution.—Philippine Islands, 604 to 772 fathoms.

Specimens examined.—Besides the type, 11, from the following stations:

Station 5215, east of Masbate, 604 fathoms, green mud; 1 specimen.

Station 5487, between Leyte and Mindanao, 732 fathoms, green mud, bottom temperature 52.3° F.; 3 specimens.

Station 5488, same locality, 772 fathoms, green mud, bottom temperature 52.3° F.; 3 specimens.

Station 5494, same locality, 678 fathoms, green mud and sand, bottom temperature 53.3° F.; 3 specimens.

Station 5515, Iligan Bay, north coast Mindanao, "about 700 fathoms."

Remarks.—There are 2 multicostate forms described by Alcock from the Indian region, *B. andamanica* $\left(\frac{i}{o+1}+I\right)$, and *B. gunnii* $\left(\frac{i}{o+1}+I\right)$, having practically the same adambulacral formula as the present species, although the description of *B. gunnii* does not state the location of the smaller actinal spine. The formula might be $\left(\frac{i+1}{o}+I\right)$. From *B. andamanica*, this species differs in having more closely crowded costae, with strongly, not feebly developed plates, in having a longer costal region, in lacking well-developed bands of pedicellariae between the costae, in having fewer (12 or 13, not 15) less deciduous rays, and a relatively longer minor subambulacral spine (the adoral). *B. gunnii* differs in having more numerous rays, much thinner disk, which has a downy appearance (spiny in *trachydisca*), only 20–30 ridges, especially prominent laterally but becoming inconspicuous or obsolete abactinally, intercostal bands of pedicellariae, a much shorter major subambulacral spine (*I* of formula), a slightly shorter minor subambulacral spine, and mouth plates composed of 2 incompletely fused abambulacrals, leaving a "ligamentous symphysis between."

Genus CRATEROBRISINGA Fisher.

Craterobrisinga FISHER (subgenus), 1916*b*, p. 33; 1917*f*, p. 624. Type, *B. panopla* Fisher.

Diagnosis.—Differing from typical *Brisinga* (which it resembles in appearance and in the possession of serial gonads, and of closely opposed first adambulacral and first marginal plates of adjacent rays) in having proximally 2 subambulacral spines of conspicuous size, the larger of which (and also sometimes the smaller) has an enlarged, modified, capitate, often truncate tip. Costae usually numerous, and genital region extended; first adambulacral plate, and sometimes the first 2, joined to corresponding plate or plates of the adjacent ray, or if rays are less than 10, the joined pair of first marginal plates may be more or less interpolated between the distal ends of the first adambulacral plates. But the first adambulacral plates of adjacent rays are never separated to their proximal ends so that the mouth plates form the apex of the interradial angle as in *Brisingella.* No matter what the number of rays may be, the first pair of marginal plates is closely apposed for the whole length of the plate, and, as stated above, their lower sides may be squeezed in between the outer ends of the first or interradial pair of adambulacral plates. When there are fewer than 10 rays these plates descend and separate the outer ends of the normally united pair of adambulacrals in such a way that the marginals can be seen from below. This seems to be a means of strengthening the actinostomial ring. A nonmuscular symphysis or syzygy between the first and second adambulacral plates, and between the dorsal end of the second and third ambulacral ossicles. Adambulacral plates short, with a crowded, characteristic armature consisting of an aboral, obliquely transverse series of 2 subambulacral spines and 1 or 2 furrow spinelets, and usually also 1 adoral spinelet. The lateral spines and the major adambulacral spines are typically long and bristling. Mouth plates small, with 1 to 3 suboral spines.

Remarks.—This genus is not so sharply differentiated as either *Brisingella* or *Stegnobrisinga*, but is readily to be recognized by the crowded adambulacral armature and the curiously modified, capitate proximal subambulacral spines, which are similar to those of *Brisingaster* de Loriol.

The species to be included in this group are: *Craterobrisinga panopla* (Fisher), *C. parallela* (Koehler), *C. cricophora* (Sladen), *C. alberti* (Fisher), *C. eucoryne* (Fisher), *C. analoga* (Fisher), *C. variispina* (Ludwig), *C. multicostata* (Verrill), and probably also the aberrant *C. evermanni* (Fisher). In the last species the proximal subambulacral spines are longer and slenderer than is usual in *Craterobrisinga*, and the modified tip is not so heavy as in typical species, nor is the adambulacral armature so crowded. The second subambulacral spine is frequently quite small and easily mistaken for an aboral furrow spinelet, but on certain plates, without any regularity that I can discover, this inner subambulacral spine becomes nearly as large as the outer. On such plates there is usually also an aboral furrow spinelet, making 3 in an oblique transverse series, with the lateral spine additional, if such happens to be present. These enlarged, inner subambulacral spines are present on the outer part of the costal region and beyond and are not shown in the figures of the adambulacral plates given by me in connection with the original description (Fisher, 1906, pl. 48, figs. 2, 2*a*). In these figures only the dwarfed inner subambulacral spines are shown. The adoral spinelet appears never to be present.

CRATEROBRISINGA EUCORYNE Fisher.

Plate 143, fig. 3; plate 148, figs. 4–6; plate 149, fig. 2; plate 154, figs. 1*a*–*c*.

Brisinga (*Craterobrisinga*) *eucoryne* Fisher, 1916*b*, p. 33.
Craterobrisinga eucoryne Fisher, 1917*f*, p. 426.

Diagnosis.—Rays 11. Related to *C. alberti* (Fisher). Five or 6 inconspicuous rudimentary costae at base of ray, followed by 17 to 20 well-spaced prominent ridges occupying proximal third of ray; numerous small integumentary spinelets, and about 3 inconspicuous bands of pedicellariae between the costae, which are composed of elongate elliptical plates, usually not compressed, bearing 1 or 2 spinelets in center; disk small, with crowded, rather long, solitary spinelets giving a hirsute appearance; adambulacral plates proximally wider than long with crowded armature; first dozen plates with also the slenderer of the 2 subambulacrals often truncate and slightly flaring; typical formulæ $\frac{i+I}{i}+I$ or $\frac{i+I+I}{i\ \ (+I)}$; 2 (instead of 1) large subambulacral spines characteristic; each mouth plate with 2 large pointed suboral spines. Breadth of disk=3⅓ times width of ray at base (6 mm.); actinostome=2 times same; height of disk=¾ breadth of ray at base. R=205+mm. r=10.5 mm. (small section from tip of ray missing).

Description.—Disk small, with an abrupt rounded border and rather prominent, vertical, interradial plates. Disk covered with relatively long, solitary, delicate, glassy spinelets, which by reason of their thick saccular investment have usually a blunt papilliform appearance and give a hirsute appearance to the disk. These spinelets are about 0.75 mm. long, are longest at center of disk, decreasing to 0.5 mm. at the margin, and are spaced one-fourth to one-third their length. The spinelets are frequently directed toward a common center forming conical groups resembling incipient spiniform pedicellariae. Scattered among the spinelets are relatively few forcipiform pedicellariae of small size.

Rays relatively short, swollen on the costal region, which occupies the proximal third of ray. At the base of ray are 5 or 6 inconspicuous costae, followed by 17 to 20 well-spaced, fairly prominent costae, which in the midradial region are almost always distorted in some way. The plates composing the ridges are not compressed. Each plate is very distinct and is in form a long, slender ellipse, constricted slightly in the middle where there is a short, upright, slender, sharp spinelet (sometimes 2). The surface of the plates is usually evenly rounded except for the central boss, and the ends are spatulate and overlapping. The integument between the ribs is thin and is provided with delicate glassy prickles about half or two-thirds the length of the costal spinelets. These are very numerous on the proximal third of the costal area, gradually thinning out until there are few or none in the last 5 or 6 intercostal spaces. There are about 3 very inconspicuous bands of pedicellariae between the costae and relatively few pedicellariae on the ridge itself. Lateral spines, beginning at about the fourth costa, articulated to a small subtriangular plate, which occurs opposite every other adambulacral, but occasionally opposite 2 consecutive plates. The first spine is very short, but they rapidly increase in size, attaining the maximum length (12 or 13 mm.) near the end of the costal region, where they are as long as 5½ consecutive adambulacral plates, and very slender.

Adambulacral plates proximally wider than long, with a crowded armature, which for the first few plates has the formula $\frac{i+1}{i}+I$ on the fourth or fifth plate becoming $\frac{i+I}{i}+I$ or $\frac{i}{i}+I+I$; then to $\frac{i+I+I}{i}$ or $\frac{i+I+I}{i+1}$. At either end of the plate pointing across furrow is a slender spinelet, usually a little longer than the plate, but if there is an adoral actinal spinule the furrow spinelet is shorter. On the actinal surface are 2 large actinal grooved spines sometimes in a transverse series at middle of plate, or in an oblique series from the inner aboral toward outer adoral corner. The outer spine on the first 10 plates has a flaring truncate tip, ending in numerous points, which is broadest on the most proximal spines, thence decreasing in width as the spine increases in length. The eleventh is usually also truncate, but from here on the spines become pointed. The first spine is equal to 3½ consecutive (short) adambulacrals, the eleventh. 4½ or 5 (or the first 7 plates of the ray); thence the spines become slenderer and longer, equaling 6½ to 7 consecutive, longer, adambulacral plates on the outer part of the costal region. The other actinal spine on the first 2 or 3 plates is slender, pointed, and about three-fourths the length of the very stout outer subambulacral. From the fourth to the twelfth it varies from three-fourths to the length of the outer spine, but is slenderer and frequently has a truncate, slightly flaring tip, though often also a bluntly pointed one. Beyond about the twelfth plate it is two-thirds to four-fifths the length of the outer spine, is slenderer than proximally, and always is acicular. A variable number of plates have an adoral actinal spine, one and a half to twice the length of the adoral furrow spine. This species has an unusually long secondary actinal spine. Spines covered with pedicellariae.

Mouth plates small. Armature consists of a spinelet at outer furrow corner and 2 at the inner, one directed across mouth of furrow and the other, which is near median suture, is directed over actinostome. These spinelets are a little more than half to three-fourths length of plate. The median suture on its outer half is abruptly much wider than on the inner half. (2) There are 2 suboral pointed spines, heavily sheathed with pedicellariae, one at either end of the plate, their bases occupying most of the surface of the plate. They are 2 to 2½ times the length of the mouth plates, and they vary somewhat in robustness. The inner is a little the larger. Sometimes the tip is bifid.

Madreporic body very small and prominent, with a few meandering striae. The articular surface of the ambulacral plate, at junction of ray with disk, unusually small, higher than wide, with a very conspicuous suture (broader at the bottom) between the two plates.

Gonads numerous, serially arranged; interradial pair of adambulacral plates and first pair of marginal plates all closely united.

Type.—Cat. No. 37024, U.S.N.M.

Type-locality.—Station 5348, Palawan Passage, 375 fathoms, coral sand, bottom temperature 56.4° F., 2 specimens.

Distribution.—Known only from vicinity of type-locality.

Specimens examined.—Besides the types, a fragment of a ray from station 5349, near type-locality, 730 fathoms, coral sand; bottom temperature 40.6° (identification not positive).

Remarks.—This species closely resembles *C. alberti* from the Hawaiian Islands. It differs in having 11 rays which are relatively narrower at the base (9 in *alberti*); longer and thicker proximal subambulacral spines, the inner of the two being nearly as long as the outer on the first 10 or 12 plates, and sometimes also with an expanded tip; relatively longer secondary subambulacral spines throughout ray; larger suboral spines 2 in number instead of usually 3; longer disk spinelets; narrower articulation surfaces of ambulacral plates where the ray joins disk. The differences between this and the following species are detailed under *C. analoga.*

CRATEROBRISINGA ANALOGA, new species.

Plate 148, figs. 7, 8; plate 149, fig. 1.

Diagnosis.—Rays 11. Closely related to *C. eucoryne*, from which it differs in having more numerous costal ridges, which occupy a little more than the basal half of the ray, these ridges being also more regular, more nearly parallel, and closer together on the swollen portion of the ray; instead of 5 or 6 rudimentary ridges at base of ray, as in *eucoryne*, there are only 1 or 2; disk with slightly shorter spinelets. R=235 mm., r=10 mm.

Description.—The disk is very similar to that of *eucoryne*, but the spinelets are a trifle shorter, a character which may or may not be constant. The costal region extends a little over half the length of the ray instead of a third, and there are about 35 costae, 1 or 2 at the base of the ray being incomplete and the last 10 very slender, but complete. The costae on the main swollen portion of the costal region are closer together than in *eucoryne*, more regular, and more nearly parallel. Two adambulacral plates, each with a rib opposite, are followed by a plate without a ridge; then come two ridges close together: then may follow 2 costae opposite alternate plates, and so on. There is much variation, but beyond the fifteenth or sixteenth costa they occur only opposite alternate plates. The proximal lateral spines seem to be a trifle weaker than in *eucoryne.*

The adambulacral armature is very similar to that of *C. eucoryne*, with the exception that there is never an adoral subambulacral spinule in addition to the adoral furrow spinelet. The adoral furrow spinelet in *analoga* is probably really an actinal spinelet moved to the furrow margin. The furrow spinelets are a little less to a little more than the length of the plate. The second subambulacral is a little stouter and more often truncate on the first dozen plates than in *eucoryne.*

The pedicellariae are similar to those of *eucoryne*, but are a trifle narrower.

Type.—Cat. No. 37034, U.S.N.M.

Type-locality.—Station 5348, Palawan Passage, 375 fathoms, coral sand; bottom temperature, 56.4° F.; one specimen.

Distribution.—Known only from the type-locality.

Remarks.—The specimen upon which this species is based was in the same bottle with two of *C. eucoryne*. *B. parallela* holds a somewhat analogous position with reference to *C. panopla*, both *analoga* and *parallela* differing from their near relatives in having more regular and more nearly parallel costal arches. *B. analoga* is at once separable from both *panopla* and *parallela* in having tegumentary prickles and much fewer costae.

Genus BRISINGENES Fisher.

Brisingenes Fisher, 1917*f*, pp. 419, 427. Type, *Brisinga mimica* Fisher.

Diagnosis.—Closely similar in appearance to typical *Brisinga*, but differing in having on the margin of disk, directly over the first pair of enlarged ambulacral plates of each ray, a pair of papulae. There is thus a circle of these papulae, twice as numerous as the number of rays, and the papulae of each pair are separated slightly less than the space between the pairs. Gonads numerous, in close series on either side of each ray; first adambulacral plate and first marginal plate joined for their whole length to the respective plates of adjacent ray; thus there are 4 closely joined plates in each interradius: a nonmuscular symphysis or syzygy between first and second adambulacral plates and between the dorsal part of the second and third ambulacral plates, as in *Brisinga*.

Remarks.—The two species which are included in this genus are in most respects closely similar to *Brisinga*, s. s., except for the regular circle of papulae near the margin of the disk, there being 2 papulae for each radius. The first pair of adambulacral plates is more closely joined than in true *Brisinga*, judging by the figure of *B. endecacnemos* Asbjørnsen, given by G. O. Sars (1875, pl. 7, figs. 8 and 9.), and the condition of these plates in *B. trachydisca*. The outer ends of the plates tend to radiate apart somewhat, and in the second species the united first pair of marginals slips down between them.

KEY TO THE SPECIES OF BRISINGENES HEREIN DESCRIBED.

a^1. Conspicuous costae 25 to 30, occupying proximal fifth of ray; pedicellariae larger, the proximal serrate edge of each blade inconspicuous, semicircular; articular surface of proximal ambulacral ossicles smaller; rays 16 ---------- *mimica*, p. 518

a^2. Conspicuous costae about 40, occupying proximal fourth of ray; pedicellariae smaller, with the proximal serrate edge of each blade relatively larger in proportion to total length of blade and different in form; articular surface of proximal ambulacral ossicles larger, the pair being 1.5 times higher than broad; rays 14 ---------- *anchista*, p. 521

BRISINGENES MIMICA (Fisher).

Plate 147, figs. 3–5; plate 149, fig. 4; plate 152, figs. 4, 4*a–d*.

Brisinga mimica Fisher, 1916*b*, p. 32.
Brisingenes mimica Fisher, 1917*f*, p. 427.

Diagnosis.—Rays 16. Costae numerous (25 to 30), closely placed, prominent, irregular, with relatively coarse spinelets, without intervening bands of pedicellariae; costae confined to basal fifth of ray, beyond which for an equal distance are about 15 very inconspicuous ridges composed of small plates, but carrying a fairly heavy felting of pedicellariae; disk large, with isolated delicate spinelets not in groups; adambulacral plates proximally wider than long and crowded in appearance; armature typically 1 aboral furrow spinelet, 1 aboral actinal spinule and 1 longer adoral actinal spine (equaling 2 plates in length), and 1 major spine about 3 plates in length. Rays slender, very long; R=385 mm., r=19 mm.

Description.—Disk large, with rounded borders. The small, granuliform abactinal plates, with solitary, delicate spinelets, about 0.75 mm. long and spaced about their own length, give the abactinal surface of disk a very finely hirsute or downy appearance.

Thickly scattered among the spinelets are relatively large, forcipiform pedicellariae with very slender jaws. In *B. anchista* the pedicellariae are minute.

Rays very long, swollen beyond the base by the gonads. Prominent costae 25 to 30 confined to basal fifth of ray, beyond which for an equal distance are about 15 very inconspicuous ridges composed of small plates, but carrying a fairly heavy felting of pedicellariae. The prominent costae are in the form of narrow, elevated, irregular ridges, bearing comparatively coarse spinelets, 2 or 3 to a plate. No intercostal felted bands of pedicellariae until beyond the region of prominent costae, where the bands occur at regular intervals but are not particularly prominent. Dorsal integument very thin. No integumentary prickles. About 5 closely joined lateral (or marginal) plates at base of ray, beyond which on the first prominent lateral plate is a tiny sharp, decidious lateral spine, which increases rapidly in length until at the outer end of the costal region it is about 12 mm. long or 5.5 times the length of an adambulacral plate. The lateral spines are opposite every other adambulacral plate and proximally their plate forms the base of a costal arch. There is also a costal arch between every 2 lateral spines, but these have no prominent marginal plates, as do the alternate arches.

Adambulacral plates crowded; near the disk viewed from the side, their height equals 1.5 their length, and width actinally equals 1.25 times length measured in the middle, or about the length measured on furrow margin. Opposite the last prominent costae the dimensions are relatively nearly the same and it is not until the middle of ray that the length begins to exceed the width. The typical formula for costal region is $\frac{i+\mathit{1}+I}{\mathit{1}}$. Sometimes the formula seems to be $\frac{ii+I}{\mathit{1}}$, because the minor aboral spinule (*1*) moves furrowward and stands close to the true furrow spinelet but even then is usually directed at an angle from the latter. The aboral furrow spinelet is about 1.25 the length of the plate, the minor aboral actinal spinule varying from slightly more to slightly less than the above. The large actinal spine equals 3 plates in length and the adoral actinal spine 2. On the outer attenuate part of ray the formula is $\frac{i+I}{i}$, the adoral actinal spinelet having moved fairly into the furrow. On some the large spine stands exactly in the middle, the formula then being $\frac{i}{i}+\mathrm{I}$. The spines are all fluted and richly provided with pedicellariae, which also occur on the surface of the plate.

Mouth plates with the following armature: a furrow spine at either end of the furrow margin about equal in length to width of combined plates at middle; an actinostomial spinelet just mesad to the base of the inner furrow spine; at outer end of plate a long acicular suboral spine usually joined with its fellow in a common sheath which is prolonged beyond the tip. All are heavily clad with pedicellariae.

Madreporic body very small, on rounded margin of ray. The articular surface of the pair of ambulacrals of the disk, where a ray has been broken off, is oblong elliptical in form, not oval as in *B. trachydisca*, and the height is equal to $1\frac{1}{3}$ times combined width.

The pedicellariae are distinctly larger than those of *B. anchista*, being 0.4 to 0.5 mm. long. In the case of the pedicellariae of the furrow spinelets, the proximal serrate portion of the jaw has fewer teeth than in *anchista*, and is relatively smaller in proportion to the length of the jaw (see figures).

The papulae, gonads, first adambulacral and first marginal plates as in generic description.

Type.—Cat. No. 37021, U.S.N.M.

Type-locality.—Station 5648, Buton Strait, Celebes (lat. 5° 35′ S.; long. 122° 20′ E.), 559 fathoms, green mud; bottom temperature 39.2 F.

Distribution.—Known only from type-locality.

Remarks.—This species differs from *Brisinga insularum* Alcock and Wood-Mason in having 16 instead of 13 rays, isolated disk spinelets, not tufts, no intercostal ridges of pedicellariae, more numerous costal ridges (13–17 in *insularum*), a small madreporic body, much shorter lateral spines (= 5.5 adambulacral plates as against 10 or 12 in *insularum*), somewhat shorter major subambulacral spine, longer adoral minor subambulacral spine. If I understand the arrangements of spines correctly, the formula for *insularum* would be $\frac{i+1}{0+1}+\mathrm{I}$, which numerically is the same as the most characteristic formula of *mimica*. *B. bengalensis* has 14 rays, a small disk, with the abactinal spinelets in tufts, 20 costae occupying basal ninth of the ray, and intercostal bands of pedicellariae equally salient with the ribs. The adambulacral formula is similar to that of *mimica*, but the minor adoral and aboral subambulacral spines are not half as long as their plate, from which it may be surmised that the plates themselves are longer than in *mimica*, and the aforesaid spines shorter. They may also be true furrow spinelets in the sense I have used the term, in which case the formula would be a bit unusual, $\frac{ii}{i}+\mathrm{I}$. Of course the generic position of *B. insularum* and *B. bengalensis* is not yet ascertained.

This species superficially resembles *Stegnobrisinga placoderma*, which I have placed in a separate genus. The types of both species were taken at the same haul.

BRISINGENES ANCHISTA, new species.

Plate 146; plate 153, figs. 3, 3*a–d*; plate 154, fig. 4.

Diagnosis.—Closely resembling *B. mimica*, but differing in having 14 rays, smaller pedicellariae, of which the proximal serrate portion of each blade has more numerous teeth, and is of different form; in having more numerous and more regular prominent costae, longer costal region, longer oral spines at mouth of furrow, longer mouth plates, and decidedly larger articular surface to the ambulacral plates, where ray is detached from disk. Adambulacral armature typically $\frac{i+1+I}{1}$. Breadth of disk=4½ times width of ray at base; actinostome=3 times same; height of disk=breadth of ray at base. R=360+mm., r=19 mm. (tip of ray missing). Rays, 14.

Description.—Disk covered with fine spinelets, 1 to a plate, spaced about their own length (0.5 mm.) apart and decreasing very slightly in length toward the center of disk. Many of the spinelets have a small pedicellaria attached to them, distinguished from those of *S. placoderma* and *B. mimica* by difference in form and smaller size. The margin of disk is rounded and at the base of each ray, on this rounded border, are a couple of prominent papulae.

Rays long, distally slender, swollen beyond the base into a depressed genital region. The difference in the costal region between *mimica* and *anchista* is not great, but easily discernible, especially if the rays are placed side by side. In *anchista* there are about 40 prominent costae which occupy the proximal fourth of the ray, and in addition there are about 10 or 12 very slender ridges beyond these. The costae are straighter; that is, less sinuous, as a rule, than in *mimica*, and the inconspicuous distal costae are fewer and occupy less space. There is little, if any, difference in the structure of the ridges themselves. In a few of the proximal intercostal spaces are single rudimentary bands of pedicellariae. Usually the intercostal spaces are without such bands. There is a subtriangular marginal plate opposite every other adambulacral; and opposite each intervening plate is a costal ridge which has no enlarged lateral plate and usually does not touch the adambulacral. The first lateral spine is opposite about the fifteenth adambulacral plate and only 1 mm. long. At the end of the region of prominent costae they are about 10 mm. long, or the length of 4 consecutive plates; opposite the last rudimentary rib they are 16 mm. long or 6½ adambulacral plates in length. They have a heavy membranous investment.

Proximal adambulacral plates wider than long with an armature very similar—almost identical—to that of *B. mimica*. The typical formula is $\frac{i+1+I}{1}$. The principal variations are occasionally an additional aboral subambulacral spinule $\left(\frac{i+2+I}{1}\right)$, or the aboral spinule moves nearer the furrow spinule, so that the formula is more properly $\frac{ii+I}{I}$. The aboral furrow spine is a little longer than the chord of the furrow margin and slightly longer than the adjacent subambulacral spinule. The adoral subambulacral spine is usually about two plates long, measured in the middle of the actinal surface. The major spine is rather short, being 2 to 2½ plates in length at base of ray, and 3 at the end of the costal region. The saccular investment of the spines is conspicuous, often forming a wide flange or sheet of tissue. Sometimes several major subambulacral spines are joined together by their sacculi (by means of pedicellariae) so that the spines appear to be merged in an actinolateral membrane.

The mouth plates are longer than those of *mimica* and the spine which is directed across the mouth of the furrow reaches the other side, being longer and stouter than in *mimica.* There is a short actinostomial spinelet and a short aboral furrow spinelet. The slender, acicular, suboral spine stands at the extreme outer end of the plate and is usually invested in a common sacculus with its fellow, as shown in the figure.

Madreporic body on the margin, rather small, and surrounded by a zone of plates free from spinelets. The articular surface of the ambulacral plates, where a ray has been broken from disk, is unusually large, the height of the pair being 1½ times the width, and about 1½ times that of the same structure in *B. mimica* (the disks are almost exactly the same size). The figure will best show the exact form.

Gonads, first adambulacral plates, and first marginal plates as in generic diagnosis.

Pedicellariae are best recognized from the figures. They are everywhere smaller than in *B. mimica.* A disk pedicellaria is about 0.25 to 0.28 mm. long (0.45 mm. in *mimica*) and the proximal serrate portion is longer in proportion to the length of the jaw. In the case of the pedicellariae from the furrow spinelets, the difference is even more noticeable (0.22 to 0.27 mm. in length, with more numerous teeth in the serrate portion). Compare, also, figures of pedicellariae from marginal mouth spines.

Type.—Cat. No. 37033, U.S.N.M.

Type-locality.—Station 5648, Buton Strait, Celebes (lat. 5° 35′ S.; long. 122° 20′ E.), 559 fathoms, green mud; bottom temperature, 39.2° F.

Distribution.—Known only from the type-locality.

Remarks.—This species might easily be confused with *B. mimica,* and superficially it greatly resembles also *Stegnobrisinga placoderma.* The types of all three were taken at the same haul, and loose arms were thoroughly mixed together. In the absence of disks, *B. anchista* may be distinguished from *B. mimica* by the size and form of the pedicellariae, and by the more numerous prominent costae. The other differences have been fully detailed in the diagnosis and description. (See also the key.)

Genus **BRISINGELLA** Fisher.

Brisingella FISHER, 1917*f*, pp. 423, 427, figs. 5 and 6. Type, *Brisinga fragilis* Fisher.

Diagnosis.—Differing from typical *Brisinga* in having only one gonad on either side of each ray; in having the first adambulacral plate separated from that of the adjacent ray by the outer ends of the combined mouth plates; in having the interradial pair of marginal plates joined only by the adoral ends, and forming a Y-shaped structure with the unpaired interradial plate. Rays slender, usually very deciduous, a nonmuscular symphysis or syzygy uniting the first and second adambulacral plates, and the dorsal part of the second and third ambulacral plates; adambulacral plates longer than broad, with few or no furrow spinelets, and a sharp, unmodified, subambulacral spine; integument of disk thin, weak; mouth plates small, with small suboral spine; entrance of furrow from actinostome broad.

Remarks.—This genus includes a number of species of the old genus *Brisinga* which are very distinct from the type, *B. endecacnemos.* They are outwardly distinguishable by the delicate rays which are very deciduous, by the delicate dorsal skeleton, both of disk and of rays, by the thin disk, and more definitely by the fact that the first adambulacral plate is not united with its neighbor of the adjacent ray, but is separated by the outer end of the combined mouth plates. Correlated with this the first marginal plate is not joined to its vis-à-vis, as in typical *Brisinga*, forming thus a pair of plates, snugly apposed, above the closely apposed first adambulacrals. But instead they join only by their adoral or inner ends, and with the interradial plate form a Y-shaped structure, the two arms of which represent the first marginal plates, while the acute angle represents the interbrachial angle bounded by these plates. If the lateral face of a disk which has lost several rays is examined it will be noted that the rays have broken at the syzygial or nonmuscular symphysis between the first and second adambulacral plates. In *Brisinga* one sees 2 distal facets close together and immediately above them 2 smaller, usually unequal, closely joined facets—the distal ends of the first marginal plates. The 2 lower (adambulacral) facets are slightly spaced. In *Brisingella* the adambulacral and marginal plate of each ray are joined, the latter above the former, but never those of adjacent rays. Always the interbrachial angle or sinus extends to the proximal end of the plates and keeps those of adjacent rays apart.

More important still, in *Brisinga* the gonads are numerous in each ray and form a series of independent bodies along either side of the genital region. In *Brisingella* there are always 2 gonads to each ray, and although they may be branched each gonad has but a single aperture on the side of the ray at a little distance from the base (see Sars, 1875, pl. 1, fig. 12*a*).

Brisingella includes the following species: *B. fragilis* (Fisher), *B. coronata* (G. O. Sars), *B. exilis* (Fisher)), *B. pusilla* (Fisher), *B. tenella* (Ludwig), and probably the following species described by Sladen; *B. verticillata*, *B. armillata*, *B. discincta*, and *B. membranacea*. *B. mediterranea* (Perrier) probably belongs in this genus, although the gonads are not described.

In his paper entitled Researches on the Structure and Affinity of the Genus Brisinga, based on the study of a new species, Brisinga coronata, George Ossian Sars describes and beautifully figures the anatomy of *Brisingella coronata* and *Brisinga endecacnemos*. The former is a typical *Brisingella*, and the special differential characters are clearly shown on plate 3 (several figures of the gonads in situ and removed) and plate 4, figures 4, 5, 6 (characters of first adambulacral, marginal, and interradial plates); plate 5, figures 1, 2, 11, 12, 15 (same ossicles). For comparison, plate 7 of the same work is valuable, as the serial gonads (fig. 18) and the plates of the actinostomial ring and base of rays (figs. 2, 5, 8, and 9) of *Brisinga endecacnemos* are clearly shown. Figure 18 may be compared with figure 4, plate 3; figure 7 with figure 1, plate 4; figures 8 and 9 with figures 4, 6, and 5, of plate 4.

BRISINGELLA FRAGILIS (Fisher).

Plate 156, figs. 3, 3*a*.

Brisinga fragilis FISHER, 1906, p. 1115, pl. 46, fig. 1; pl. 48, figs. 3, 3*a–c*.
Brisingella fragilis FISHER, 1917*f*, p. 423, figs. 5 and 6, p. 427.

One specimen from station 5123, east of Mindoro, 283 fathoms, green mud; 8 detached rays, only.

There is no disk, so that the number of rays can not be ascertained. The secondary costae are almost obsolete as in variation A described and figured in the above citation. There seems to be only 1 (adoral) furrow spinelet throughout the ray, and 1 comparatively small subambulacral spine, the formula being $\overset{o+I}{\underset{i}{\cdot}}$ or $\overset{o}{\underset{i}{\cdot}}+I$. In typical *fragilis* the first few adambulacral plates have an aboral furrow spinelet thus $\overset{i+I}{\underset{i}{\cdot}}$, this extending a variable distance along the ray in the varieties. The pedicellariae of the Philippine specimens are like those of the Hawaiian.

Type-locality.—Station 3824, south coast of Molokai Island, Hawaiian Islands, 222–498 fathoms, coral rocks, broken shells.

Distribution.—Hawaiian and Philippine Islands, 253–387 fathoms.

Genus ASTROSTEPHANE Fisher.

Astrostephane FISHER, 1917*f*, pp. 421, 422, figs. 3 and 4. Type, *Brisinga moluccana* Fisher.

Diagnosis.—Differing from typical *Brisinga* in having but 2 gonads to a ray, and the proximal adambulacral plates longer than high, as in *Brisingella*. In appearance, especially that of rays, closely resembling *Brisingella*, but differing in having the first adambulacral plate tightly joined for its whole length to that of the adjacent ray, and in having directly above these a closely joined pair of first marginal plates, as in *Brisinga*, *Craterobrisinga*, *Brisingenes*, and *Stegnobrisinga;* in having very prominent suboral spines bent at the base so that they extend horizontally into the actinostome. A nonmuscular joint or syzygy between the first and second adambulacral plates and between the upper part of the second and third ambulacral plates; costae thin, well spaced; intercostal integument without spinelets and rather delicate; only 1 subambulacral spine; gonads large, with numerous lobes emptying by a single aperture just above the ambulacral plates, a little over 2 r from the base of ray; disk with close-set, small spinelets.

Remarks.—It seems probable that this genus is more nearly related to *Brisingella* than to *Brisinga*. Fortunately, there are two very distinct species, so that the characters given in the diagnosis as of generic value are probably reasonably accurate.

If it is contended that the condition of the interradial pair of adambulacral plates, whether separated (*Brisingella*, *Astrolirus*) or united (*Brisinga*, *Craterobrisinga*, *Stegnobrisinga*, *Astrostephane*), is dependent upon the number of rays, it may be stated that *A. acanthogenys*, with 11 rays, has the plates as tightly joined as *A. moluccana*, with 16 rays. In *Brisingella*, where this interradial pair of adambulacrals is separated by the outer end of the combined mouth plates, so that they do not touch by the lateral faces, the first marginal plates have a different relation, also. They form a λ with the unpaired interradial plate, each arm being applied to the upper edge of the first adambulacral plate, and the angle of the λ being that of the interradius. In *Craterobrisinga alberti* (Hawaiian Islands), which has 9 rays (less than in *Brisingella fragilis*), the mouth plates do not separate the first or interradial pair of adambulacrals as might be expected if the number of rays only determined the characteristic structure of the interradial angle of *Brisingella*. The proximal part of the plates in *alberti* are normally joined, and the *closely apposed* first pair of marginals has slipped down between the outer ends of the adambulacrals, cementing firmly the ring of plates. There is no hint of the separation of the marginals to form the λ of *Brisingella*.

KEY TO THE SPECIES OF ASTROSTEPHANE HEREIN DESCRIBED.

a^1. Rays 16, with prominent, complete costae and 1 to 3, usually 3, conspicuous intercostal bands of pedicellariae; disk medium sized, with abruptly rounded (not beveled) margin; actinostome relatively very large; 1 suboral spine to each mouth plate; disk plates with solitary spinelets only; lateral spines equal in length to 5 or 6 consecutive adambulacral plates; adambulacral armature $\frac{i+I}{i+1}$ or $\frac{i+I}{ii}$ ------------------ *moluccana*, p. 526.

a^2. Rays 11, with about 20 complete prominent costae and 1 complete and 1 or 2 incomplete bands of intercostal pedicellariae; disk decidedly small, with a beveled margin; actinostome relatively small; 2 large suboral spines to each mouth plate; disk plates with 1, 2, and 3 small spinelets in about equal numbers; lateral spines equal in length to 7 or 8 consecutive adambulacral plates; adambulacral armature $\frac{i+I}{i+1}$ ------- *acanthogenys*, p. 528.

ASTROSTEPHANE MOLUCCANA Fisher.

Plate 147, figs. 1, 2; plate 149, fig. 3; plate 154, figs. 2, 2*a–c*; plate 156, figs. 2, 2*a*.

Brisinga moluccana FISHER, 1916*b*, p. 32.
Astrostephane moluccana FISHER, 1917*f*, pp. 421, 422, figs. 3 and 4.

Diagnosis.—Rays 16. Costae 25, complete, prominent, well-spaced, with 1 to 3 intercostal bands of pedicellariae; costal spinelets relatively coarse; disk medium, with isolated, papilliform, small spinelets, and minute pedicellariae; adambulacral plates about as wide as long, proximally; armature typically $\frac{i+I}{i+1}$ or $\frac{i+I}{ii}$. Costal area swollen, occupying somewhat more than basal third of ray; integument thin, devoid of prickles. Breadth of disk=5 times width of ray at base (6 mm.); actinostome=3½ times same; height of disk=breadth of ray at base. R=110 mm., r=15 mm. (ray perfect, with long attenuate extremity).

Description.—Disk medium sized, with abruptly rounded margin; abactinal integument fairly thin. The spaced, granuliform abactinal plates each with 1 papilliform spinelet about 0.5 mm. long, or less, the calcareous part of which is delicate and sharp. The investment gives the spinelets a stubby cylindrical form; some appear to be scarcely longer than granules. Around the base of each are 5 or 6 very minute pedicellariae. The spinelets around the anal aperture are longer than the others.

Rays swollen throughout costal region, which occupies more than a third and less than a half the length of ray. Costae, about 25, very prominent, well spaced (for half or a third width of ray). They are all complete, being opposite alternate adambulacrals and are frequently bent or bowed aborad. Between them are from 1 to 3, usually 3, broad, conspicuous bands of minute pedicellariae, which are continued beyond the costal region, slightly more frequently than

1 to each adambulacral plate. The membrane between the ridges is thin and without integumentary prickles. The costae are compressed, higher than thick, and along the summit is a row of comparatively coarse, conical spinelets (one-third to one-half total height of the ridge), spaced in twos and threes. First lateral spine, usually at second complete costal ridge, acicular, sharp, equal in length to 1½ or 2 adambulacral plates. On the outer third of the costal area the spines are equal in length to 5 consecutive adambulacral plates (12 mm.) and increases to 6 at the beginning of the distal third.

Adambulacral plates of costal region about as long as wide. The armature consists of a true furrow spine at either end of the plate and equal to about two-thirds length of plate; aborad and actinad to the adoral spine is a slightly shorter one, generally pointed away from the furrow; the large actinal spine, equal to 2 to 3 plates in length, is situated on the aboral half of the plate. The formula is $\frac{i+I}{i+I}$, but on the outer half of ray is $\frac{i}{i}+I$, the small adoral second spinelet disappearing, while the large actinal spine moves to the middle of the plate. The distal plates are also longer than wide, as is generally the case. On some of the proximal plates the formula would stand $\frac{i+I}{ii}$. The spines are incased in a sheath armed with minute pedicellariae.

Mouth plates small, with 1 spine at each end of the excavated furrow margin, nearly as long as the plate. The inner of these two is strongly bent at the base. Just mesad to it is a small actinostomial spinelet, about half its length. The suboral spine, fluted and sharp, is strongly bent at the base, so that with its fellow it is pointed horizontally across the actinostome. The pedicellariae are grouped along one side only of the spines, and the sheaths are thin.

Madreporic body convex and prominent, 1.5 mm. in diameter. On the adcentral border is a conspicuous, nearly naked area composed of 7 plates. The articular surface of the ambulacrals, where a ray has been broken off, is about as broad as high, and the scar of each plate is ovoid in outline, the lower ends being bent away from each other. Gonads, first adambulacral plates, first marginal plates as in generic diagnosis.

Type.—Cat. No. 37022, U.S.N.M.

Type-locality.—Station 5626, between Gillolo and Kayoa Islands, Molucca Islands, 265 fathoms, gray mud, fine sand; 1 specimen.

Distribution.—Vicinity of Celebes and Molucca Islands, 265 to 559 fathoms.

Specimens examined.—The type and 1 arm from station 5648, Buton Strait, Celebes, 559 fathoms, green mud; bottom temperature, 39.2° F.

Remarks.—This species has more numerous rays than any of the 4 species described by Alcock, none of which have isolated spinelets on the disk, nor a similar adambulacral armature formula, with 2 furrow spinelets adorally. *Craterobrisinga evermanni* Fisher of the Hawaiian Islands resembles the present species but differs in having 15 rays, no adoral furrow spinelet $\left(\text{formula } \frac{i+1+I}{o} \text{ or } \frac{o+1+I}{o}\right)$ very much slenderer and shorter suboral spines which are not bent at the base; only a rudimentary aboral marginal mouth spinelet, or none. The superficial appearance of the rays is very similar, but the ray of *moluccana* is more depressed and relatively broader than is usual in *evermanni.* The condition of the gonads and first few subambulacral spines is quite different in the 2 species, as their generic position indicates.

ASTROSTEPHANE ACANTHOGENYS Fisher.

Plate 148, figs. 1–3; plate 153, figs. 1, 1*a–d*.

Brisinga acanthogenys Fisher, 1916*b*, p. 33.
Astrostephane acanthogenys Fisher, 1917*f*, p. 421.

Diagnosis.—Rays 11. Costae 20, complete, prominent, well-spaced, with 1 complete and 1 or 2 incomplete bands of intercostal pedicellariae; costal spinelets fairly prominent, few in number; disk small, with beveled margin; plates granuliform, spaced, with usually 2 or 3 very small spinelets, but no pedicellariae; lateral spines long, equaling length of 7 or 8 adambulacral plates; no integumentary prickles on rays; adambulacral plates about as wide as long proximally; armature proximally $\frac{i+I}{i+1}$; mouth plates with 2 suboral spines. Breadth of disk=3½ times width of ray at base (6 mm.), actinostome=2¼ times same; height of disk=three-fourths breadth of ray at base. R=350 mm. (complete ray), r=11 mm.

Description.—Disk small, the abactinal surface scarcely at all raised above abactinal surface of ray; margin beveled. The tiny granuliform platelets bear 1 to 3 extremely small, delicate, and sharp spinelets, which by reason of their membranous sheaths appear to be rather robust, tapering, and pointed. In the central part of the disk they are 0.25 to 0.3 mm. long, decreasing gradually toward the border, and are spaced about one-half to their own length; pedicellariae seem to be lacking.

Costal region swollen, occupying not quite one-third length of ray. Costae 20, complete as a rule, except in the case of the first 2 or 3; well spaced, prominent, fairly straight, and armed rather sparsely with sharp conical spinelets, about half as high as the ridge. The ridges are spaced a distance equal to three-fourths to once the width of ray at base, and midway between them is a broad band of microscopic pedicellariae, with an incomplete band on either side of this, proceeding from the adambulacral plates a variable distance toward the median line. The costal ridges are also covered with pedicellariae, and beyond the costal region the broad bands occur quite regularly opposite each lateral spine, with 1, rarely 2, between; hence 1 opposite each adambulacral plate. Lateral spines very prominent and longer than in *A. moluccana*, which this species resembles. The first spine, at the ends of the second or third rib, is quite short, slender, and sharp. The succeeding spines often stand out rigidly from the sides of the ray and occur regularly above every other adambulacral plate articulated to a prominent boss of the lateral plate. They attain their full length in the distal half of the costal region, where they are about 20 mm. long, or the length of 7 to 8 consecutive adambulacral plates.

Proximal adambulacral plates, viewed from the side, are distinctly lower than long, and they are a trifle longer than broad. On account of the adoral furrow spine, the margin appears deeply excavated. The adambulacral armature consists of 1 true furrow spinelet at each end, nearly as long as the plate, 1 adoral minor subambulacral spinule a little longer than the plate, and a major subambulacral spine situated on a prominence of the aboral half of the plate. It is equal to 3½ or 4 adambulacral plates in length and forms an oblique series with the subambulacral spinule and the adoral furrow spinelet. The formula is $\frac{i+I}{i+I}$. On the outer part of the ray it is $\frac{i+I}{i}$ or $\frac{i}{i}+I$. This armature resembles that of *A. moluccana*, but the actinal spinule is farther from the furrow and longer. The lateral and adambulacral spines have a thin felting of pedicellariae which are usually lacking on the side of the spine nearest furrow in the case of the big spines.

The armature of the mouth plates is as follows: Directed over the furrow at either end of the plate is a slender furrow spine, and mesad to the inner one a little actinostomial marginal spine about half as long; in the middle of the actinal surface is a tapering, sharp, glassy tipped suboral spine about 2½ times the length of plate and sheathed with membrane covered with pedicellariae. Between this and the outer end of the plate there is usually a second subambulacral spine, varying from slightly more than the length of the plate to the size of the primary suboral. The suboral spines are usually bent over the actinostome.

Madreporic body circular, very prominent but flat-topped, with 2 nearly equal, naked or only slightly armed plates on its inner border.

Articular surface of the ambulacral plates at junction of ray with disk considerably broader than high. Each scar is rather oval in contour, and the lower ends do not diverge very markedly from the median vertical suture. Gonads, first adambulacral plates, and first marginal plates as in generic description.

Type.—Cat. No. 37023, U.S.N.M.

Type-locality.—Station 5440, mouth of Lingayan Gulf, Luzon, 172 fathoms, fine gray sand, globigerina, bottom temperature, 53.2° F.; 1 specimen.

Distribution.—Known only from the type-locality.

Remarks.—This species resembles *A. moluccana*, but has only 11 rays, a much smaller disk with a beveled border, and 1 to 3 minute spinelets to each plate of the disk, instead of only 1, no abactinal disk pedicellariae, much longer lateral spines, and the minor subambulacral spinule is larger, as well as further from the adoral furrow spinelet. There are 2 suboral spines, relatively larger than in *moluccana.*

Genus STEGNOBRISINGA Fisher.

Stegnobrisinga FISHER (subgenus), 1916*b*, p. 33; 1917*f*, pp. 423, 428. Type, *Brisinga* (*Stegnobrisinga*) *placoderma* Fisher.

Diagnosis.—Resembling *Brisinga* in general appearance, and especially in having definite transverse skeletal ridges, or costae, on the genital region, but differing in having the integument between the costal arches of ray strengthened by many close-set, mostly contiguous or sometimes overlapping, papery, spineless plates of irregular form, completely filling the interspaces; in having 2 gonads to each ray. Proximal subambulacral spines acicular; first adambulacral plate and first marginal plate joined for their whole length to the respective plates of adjacent ray; thus there are 4 closely joined plates in each interradius; a nonmuscular symphysis, or syzygy, uniting first and second adambulacral plates and between the upper parts of the second and third ambulacral plates, as in *Brisinga.*

Remarks.—The numerous prominent costae will at once separate this genus from *Freyella* and *Freyellaster*, while the number of gonads, 2 to a ray, is an added distinguishing feature so far as *Freyellaster* is concerned. The structure of the first adambulacral plates, and the presence of proximal marginal plates will sharply distinguish *Stegnobrisinga* from *Freyella.*

The genus *Astrolirus*, type *Brisinga panamensis* Ludwig, differs from *Stegnobrisinga* in having the first adambulacral plates and first marginal plates arranged as in *Brisingella*, and in having slenderer adambulacral plates, which proximally are not higher than long.

STEGNOBRISINGA PLACODERMA (Fisher).

Plate 150; plate 153, figs. 2, 2*a–d*.

Brisinga (*Stegnobrisinga*) *placoderma* FISHER, 1916*b*, p. 34.

Diagnosis.—Rays 13 or 14. Costae 35–40, close together, and not very prominent; the intercostal areas paved with close-set, irregular, often overlapping, papery plates devoid of spinelets; costal arches fairly regular and parallel, opposite every adambulacral, or occasionally more frequent, but only every third to fifth with a lateral spine; disk with beveled border and with close-set isolated spinelets and conspicuous slender-jawed pedicellariae; adambulacral armature variable; in type usually $\frac{ii+I}{ii}$ or $\frac{i+I}{ii}$; subambulacral spine equal to about $2\frac{1}{2}$ or 3 adambulacral plates in length. Breadth of disk= $3\frac{1}{2}$–4 times width of ray at base (8 mm.); actinostome=$2\frac{3}{4}$ times same; height of disk=seven-eighths breadth of ray at base. R=370+ mm., r=17 mm. (small portion missing from tip of ray).

Description.—Disk moderately large, with a beveled border of conspicuous width, the central area sunken a bit and plane. Plates of disk small, subcircular, or irregular, and convex. Each plate bears a single, central, sharp, tapering spinelet, which from being sheathed in membrane has a papilliform appearance. These spinelets are about 0.5 mm. long and are spaced about their own length apart. In the type about a third of the plates bear also a relatively large slender-jawed pedicellaria, about as long as the spine, and attached to the plate by a slender, short stem. In the cotype these pedicellariae are nearly as numerous as the spinelets and are a little larger than those of the type.

Rays very long, swollen for a distance from base equal to a little over twice diameter of disk. Costal region proper extending about 3 times diameter of disk from base, which is also about the extent of the area paved with plates. This is less than a fourth the length of ray, but none of the rays is quite complete. For a little over twice the diameter of disk from base of ray the costae, 35 to 40 in number, are close together and fairly regular, 1, occasionally 2, opposite each adambulacral plate. The lateral spines occur only at the ends of every third to fifth arch—that is, with 1 or 2 adambulacral plates between them. The arches corresponding to the lateral spines are more prominent than the others, especially laterally. Some of the intermediate arches are rudimentary or incomplete in the middorsal region. The costal plates are irregularly elliptical or sometimes have short lateral lobes by which they are joined to the intercostal plates. Costal spinelets short, slender, tapering, sharp, all but hidden in alcoholic specimens by the thick felting of slender-jawed pedicellariae. The intercostal spaces are paved with thin overlapping paperlike plates irregular in form. Near the end of the costal area they tend to thin out first midway between 2 costae, and at the end of the costal area there is a transverse band of thin, unarmed integument between the costae, interrupted in the specimen from station 5274 in the middorsal region, where the thin plates extend beyond the costal area proper for a distance equal to 1½ disk diameters.

The plates of these rays, which have a very swollen costal area, are very slightly spaced; but aside from this the plates of the specimen from station 5274 are more closely crowded, which is due to their larger size rather than greater numbers. At base of ray there is a row of about 7 closely placed lateral plates. First lateral spine about 1 disk diameter from base; at outer end of costal area they average 4½ consecutive adambulacral plates in length and at about twice the length of costal area from disk 6½ or 7 adambulacral plates (16–18 mm.) in length.

Adambulacral plates of costal area wider than long and, viewed directly from the side, very nearly as high as long. The armature is somewhat variable, but for the proximal part of the ray is usually either $\frac{ii+I}{ii}$ or $\frac{i+I}{ii}$. The furrow spinelet at either end of plate (about as long as the plate, or the adoral a little shorter) is accompanied by a second subequal spinelet, obliquely actinad, which comports itself more like a furrow than an actinal spinelet. The adoral one, however, is often bent away from the furrow, and the formula might be written $\frac{ii+I}{i+1}$ or $\frac{i+I}{i+1}$. Some plates have $\frac{i+I}{i}$, and in the type a few $\frac{iii+I}{ii\,(\text{or } iii)}$. The subambulacral spine is, when fully developed, 2½ to 3 adambulacral plates in length and rather less than half the length of the corresponding lateral spine. The lateral and adambulacral spines are thickly covered with pedicellariae, which are lacking on the side of the large subambulacral spine toward the furrow. The furrow spinelets have relatively large pedicellariae. In the specimen from station 5274 the plates have a variable armature $\frac{i+I}{ii}$ or $\frac{ii+I}{i}$ and frequently $\frac{i+I}{i}$, but not $\frac{ii+I}{ii}$.

Mouth plates small, each with a long needlelike suboral spine 3½ to 4½ times as long as the plate and very heavily sheathed. On some mouth plates the sheath seems to be common to 2 spines, and is always very thickly covered with pedicellariae. There are 3 marginal spinelets, 1 about as long as the plate at the outer end and another at the inner end, directed across furrow, and 1 slightly shorter on the actinostomial margin. These carry numerous slender-jawed pedicellariae.

Madreporic body prominent, flat-topped, with numerous, rather coarse, interrupted, sinuous furrows. The articulation surface of the ambulacral plates at junction of ray with disk is about as broad as high, equally broad at top and bottom and with a prominent median suture.

Type.—Cat. No. 37025, U.S.N.M.

Type-locality.—Station 5618, Buton Strait, Celebes, 559 fathoms, green mud, bottom temperature 39.2° F.; the type-specimen and 2 incomplete specimens.

Distribution.—China Sea, off southern Luzon, and Buton Strait, Celebes, 525 to 559 fathoms.

Specimens examined.—In addition to the types, rays without a disk from station 5274, China Sea, vicinity of southern Luzon, 525 fathoms, gray mud and sand, bottom temperature 41.3° F.

Remarks.—*Brisinga gracilis* Koehler, from the Bay of Bengal, east of the Andaman Islands, resembles this species in having plates between the costae and at the base of the ray before the costae commence, but they bear spinelets. Koehler does not state that the plates are close together nor unusual in number, as in the case of the present species. However, in *gracilis* the costae begin at a distance from the disk and the "plates which were invisible on the dorsal surface of the disk become distinct on the rays; they are irregular, roundish, and bear each a little conical spinelet, rough and pointed, broader at the base and shorter than those on the disk." (Koehler, 1909, p. 115.) In typical *Brisinga* the spaces between the costae are either free from plates or have embryonic spaced platelets which bear each a minute spinelet or prickle, but which do not form an armor such as exists, in a more perfected form, in *Freyella.*

KEY TO THE INDO-PACIFIC SPECIES OF BRISINGA AND BRISINGA-LIKE GENERA.

In the following more or less artificial key I have not been able to assign the species described by Alcock and Wood-Mason to the newer genera described by me. They have been listed as *Brisinga.*

a^1. Intercostal integument of proximal part of ray thin, with or without rudimentary spaced plates bearing a minute spinelet; proximal subambulacral spines acicular, not broadened into a more or less truncate capitate tip.
  b^1. Intercostal membrane without integumentary prickles.
    c^1. Plates of disk each with a group of several spinelets.
      d^1. Costae numerous—more than 30.
        e^1. Costae close together, very prominent, without intercostal bands of pedicellariae; rays 12 or 13; disk moderate, with rounded margin and spinelets in groups of 2 to 6 resembling pseudopaxillae; adambulacral armature $\frac{i+I}{o+I}$ or $\frac{i}{o+I}+I$ .... *Brisinga trachydisca* Fisher.

e^2. Costae spaced with 1 or more intercostal bands of pedicellariae; rays, 15.

f^1. Costae 45, feebly developed; in addition to the large subambulacral spine (4 times the length of its plate), an aboral apophysial furrow spinelet, and 1 adoral, not so deep in furrow.
Brisinga andamanica Alcock and Wood-Mason.

f^2. Costae 30 to 35, mostly complete, prominent though compressed and narrow; in addition to the large subambulacral spine (4.5 consecutive plates in length), 1 minor aboral subambulacral spine, and sometimes an aboral apophysial furrow spinelet $\left(\text{formulas } \frac{i+1+I}{o} \text{ or } \frac{i+I}{o} \text{ or } \frac{o+1+I}{o}\right)$. The proximal subambulcral spines are slightly modified, with a truncate tip.
Craterobrisinga evermanni (Fisher).

d^2. Costae less than 30, alternating with 1 or more intercostal bands of pedicellariae.

e^1. Disk large with vertical edge; rays 13, not very deciduous; costae 13 to 17, very salient; spinelets of disk coarser; adambulacral armature $\frac{i+1}{o+1}+I$, the minor subambulacral spinelets being on furrow margin, and small major subambulacral spine 4 to 5 times length of plate------*Brisinga insularum* Alcock and Wood-Mason.

e^2. Disk small with beveled margin; rays very deciduous; major subambulacral spine 2 to 2.5 times length of plate.

f^1. Rays 14, not very fragile; costae about 20, close together on basal ninth of ray, and not much more salient than the bands of felted pedicellariae; adambulacral armature $\frac{i+1}{o+1}+I$. ----------
Brisinga bengalensis Alcock and Wood-Mason.

f^2. Rays 14 or 15, very fragile, slender; costae 20 to 30, very contorted, salient laterally, inconspicuous abactinally; disk very thin, with a downy appearance; adambulcral armature $\frac{i+o}{o+1}+I$.
------------------------------------*Brisinga gunnii* Alcock.

f^3. Rays 11, costae 20; adambulcral armature $\frac{i+I}{i+1}$; see below.
Astrostephane acanthogenys (Fisher).

c^2. Most or all of the disk plates with a single spinelet; sometimes a few near margin with 2 or 3.

d^1. Rays more than 10; rays not especially fragile, though deciduous; suboral spines large; first pair of adambulcral plates and first pair of marginal plates in each interbrachium joined by their lateral faces.

e^1. Costae generally opposite each adambulcral plate, hence close together, and without conspicuous bands of intercostal pedicellariae; a single series of papulae around the disk close to edge, 2 opposite base of each ray.

f^1. Conspicuous costae 25 to 30, occupying proximal fifth of ray; pedicellariae larger, the proximal serrate edge of each blade inconspicuous, semicircular; articular surface of proximal ambulacral ossicles smaller; rays 16. *Brisingenes mimica* (Fisher).

f^2. Conspicuous costae about 40, occupying proximal fourth of ray; pedicellariae smaller with the proximal serrate edge of each blade relatively larger in proportion to total length of blade and different in form; articular surface of proximal ambulacral ossicles larger, the pair being 1.5 times higher than broad; rays 14____________________________*Brisingenes anchista* (Fisher).

e^2. Costae opposite alternate ambulacral plates, hence well spaced; with conspicuous intercostal bands of pedicellariae.

f^1. Rays 15; costae 30 to 35; disk medium, some of its plates with more than 1 spinelet; adambulacral formula $\frac{i+1+I}{o}$ or $\frac{o+1+I}{o}$; suboral spine rather small and delicate; gonads serial, more than 2 to each ray; proximal subambulacral spines slightly modified, blunt___________*Craterobrisinga evermanni* (Fisher).

f^2. Rays 16, with 25 prominent, complete, costae and 1 to 3, usually 3, conspicuous intercostal bands of pedicellariae; disk medium-sized with abruptly rounded (not beveled) margin; actinostome relatively very large; 1 suboral spine to each mouth plate and with an angle at base so that it is directed into actinostome; disk plates with solitary spinelets only; lateral spines equal in length to 5 or 6 consecutive adambulacral plates; adambulacral armature $\frac{i+I}{i+1}$ or $\frac{i+I}{ii}$; gonads 2 to each ray.

Astrostephane moluccana (Fisher).

f^3. Rays 11, with about 20 complete, prominent costae and 1 complete, and 1 or 2 incomplete, bands of intercostal pedicellariae; disk, decidedly small with a beveled margin; actinostome relatively small; 2 large suboral spines to each mouth plate; disk plates with 1, 2, and 3 small spinelets in about equal numbers; lateral spines equal in length to 7 or 8 consecutive adambulacral plates; ambulacral armature $\frac{i+I}{i+1}$; gonads 2 to each ray.

Astrostephane acanthogenys (Fisher).

d^2. Rays 10 or less; rays very fragile; disk small; suboral spines small; first pair of adambulacral plates of interbrachium not joined by lateral face; first pair of marginal plates joined by adoral end of plates only; gonads 2 to each ray.

e^1. Rays 10; costae rather variable, usually 24 to 28 complete ones and a varying number of intermediate incomplete ridges in the median area; marginal mouth spinelets 4, 3 on the actinostomial margin; suboral spines 2, small_____________*Brisingella fragilis* (Fisher).

e^2. Rays 7; costae few—less than 15; marginal oral spinelets 2 on actinostomial margin; 1 small suboral spine; a few isolated spicules in the intercostal integument.

Brisingella armillata (Sladen).

b^2. Tegumentary prickles in abactinal membrane of ray.

c^1. Rays 13 to 14; base of ray for some distance provided with conspicuous prickles springing from irregular roundish plates, which do not form definite costae; intercostal plates beyond this basal area usually unarmed; costae 18 to 24, the alternate ones complete, and the first at a distance about equal to r from the base of ray.

Stegnobrisinga gracilis (Koehler).

c^2. Rays 7, costae few, less than 15; tegumentary prickles few.

Brisingella armillata (Sladen).

a^2. Intercostal integument of proximal part of ray thin, with or without rudimentary spaced plates bearing tegumentary prickles; 1 or 2 subambulacral spines of proximal adambulacral plates with a modified, more or less truncate, capitate, sometimes papillose lip.

b^1. Intercostal membrane without tegumentary prickles; costae numerous, close together, without intercostal bands of pedicellariae on the proximal half of the costal region; a costal arch opposite each adambulacral plate.

c^1. Costae decidedly irregular in the median radial region; costal spinelets equal in length to height of costal ridges, or slightly exceeding same; costae 35 to 50 ------------------ *Craterobrisinga panopla* (Fisher).

c^2. Costae regular and parallel in the median radial region, passing directly from one margin to the other; costal spinelets shorter, less than height of ridges; costae upward of 80.

Craterobrisinga parallela (Koehler).

b^2. Intercostal membrane with tegumentary prickles; intercostal spaces with bands of pedicellariae, sometimes inconspicuous; costal arches usually not regularly opposite each adambulacral plate, but variable.

c^1. Rays 9; proximal adambulacral plates with only 1 capitate subambulacral spine, the associated spinule being conspicuously smaller, and truncate or bluntly pointed; suboral spines usually 3, small.

Craterobrisinga alberti (Fisher).

c^2. Rays 11; proximal adambulacral plates with usually the second subambulacral truncate and slightly capitate, and nearly as long as, though slenderer than, its companion; suboral spines 2, large.

d^1. Costae 17 to 20 (in addition to 5 or 6 rudimentary ones at base of ray), well spaced, prominent, rather irregular, and occupying about the proximal third of ray ------ *Craterobrisinga eucoryne* (Fisher).

d^2. Costae about 35 (in addition to only 1 or 2 rudimentary ones at base of ray), but last 10 are inconspicuous; costal region occupying about half length of ray; costae fairly regular and parallel and the proximal ones closer together than in d^1.

Craterobrisinga analoga Fisher.

b^3. Intercostal integument without tegumentary prickles and with conspicuous intercostal bands of pedicellariae; costae opposite alternate ambulacral plates, hence well spaced; rays 15; costae 30 to 35; disk medium, some of its plates with more than 1 spinelet; suboral spine rather small and delicate; proximal subambulacral spines only slightly modified, truncate -------------------------- *Craterobrisinga evermanni* (Fisher).

a^2. Intercostal integument of most of costal region strengthened by many close-set, contiguous, or overlapping papery plates of conspicuous size, completely filling the interspaces; proximal subambulacral spines acicular.

b^1. Costae 35 to 40, beginning at base of ray; no intercostal spinelets, the plates being smooth; first subambulacral spine pointed.

Stegnobrisinga placoderma (Fisher).

b^2. Costae 18 to 24, the alternate ones complete, and beginning at a conspicuous distance from disk, the interval being covered with irregularly disposed, spiniferous plates without arches; intercostal plates beyond this spiniferous basal area without spinelets; first subambulacral spine slightly broadened at tip, the following spines acicular.

Stegnobrisinga gracilis (Koehler).[1]

---

[1] I am not sure of the generic position of this species, as the gonads and condition of the first adambulacral plates are not known to me.

Genus FREYELLASTER Fisher.

Freyella FISHER, not Perrier, 1917*f*, pp. 424, 428.

Freyellaster FISHER, 1918, p. 103. Type, *Freyella fecunda* Fisher.

Diagnosis.—Brisingidae with numerous gonads arranged serially along either side of the more or less inflated genital region of ray, each opening by its own pore; plates of genital region forming a continuous covering or armor, more or less spiniferous, and not segregated as independent skeletal arches, separated by intervals without plates: no papulae; in interbrachial angle the first pair of adambulacral plates (of adjacent rays) closely joined throughout their length, and directly above them is a pair of closely joined first marginal plates; primary apical plates not conspicuous; a nonmuscular symphysis or syzygy between the first and second adambulacral plates, and between the upper part of the second and third ambulacral plates.

Remarks.—This group includes those species of the old genus *Freyella* in which the gonads are numerous and arranged in series along either side of the ray, as in typical *Brisinga.* In this restricted genus *Freyellaster*, as in the restricted *Brisinga*, the first adambulacral plate is closely united to its fellow of the adjacent ray, at the apex of the interbrachial angle; and immediately above them, and joined to their upper sides is a closely apposed pair of marginal plates, the first of a series which extends a variable distance along the base of the ray, just above the adambulacral plates. The adoral end of these marginal plates abuts against the base of the interradial plate. In some species part of the second adambulacral plate, as well as the first, is joined to its vis-à-vis.

In a preliminary revision of the Brisingidae (Fisher 1917 *f*) I divided the old genus *Freyella* into two groups, *Freyella* and *Freyellidea.* The name *Freyella* was restricted to those species having supposedly the characters enumerated in the preceding paragraph, and *Freyella spinosa* Perrier was kept as the genotype. The name *Freyellidea* was bestowed upon the group called *Freyella* in the foregoing synopsis of genera. Unfortunately the most important characters of *Freyella spinosa* are not shown in Perrier's figures nor mentioned in the description, since such details have generally been omitted as of no particular importance.

Through the courtesy of Dr. H. L. Clark, of the Museum of Comparative Zoology, I subsequently examined an authentic example of *Freyella spinosa* received from the Muséum d'Histoire Naturelle. It belongs to the group which I called *Freyellidea.* This specimen, No. 1447, has two gonads to each ray, each gonad consisting of a good-sized clump of tubules with a single aperture to the exterior. There is no syzygy between the first and second adambulacral plates; no syzygial joint between the upper end of the second and third ambulacral ossicles, although the interval is very narrow; there are no superomarginals directly above the first adambulacrals. The first and second, and in one interbrachium also the third, adambulacral plates are joined to the corresponding adjacent plates of the next ray, although not so closely as in the other generic group, there being considerable tissue between the apposed plates. It was this feature, figured by Perrier, which led me to suppose that *F. spinosa* belonged with the group containing *F. fecunda*, *F. spatulifera*, and others, in which the first adambulacrals are always tightly joined. For the present it is best to consider this character as of secondary importance in true *Freyella*, which is really not very closely related to the genus containing *F. fecunda.* The latter is distinguished by a syzygy, well-developed marginals for the interbrachium, and serial gonads.

The species which I have personally examined are *Freyellaster fecundus* Fisher (California), *Freyellaster spatulifer* (Fisher), and *Freyellaster scalaris* (A. H. Clark) (Galapagos Islands). Among the species described by Sladen in the *Challenger* report, *Freyella polycnema* appears to belong here.

I have examined the following species which belong to the genus *Freyella: spinosa* Perrier, *elegans* Verrill, *insignis* Ludwig, *propinqua* Ludwig, *pacifica* Ludwig, and *microplax* Fisher. Without knowing the disposition of the gonads it is not possible to be certain that the following species belong in *Freyella.* As nearly as can be judged by the figures given they appear to. Such species are: *sexradiata* Perrier, *benthophila* Sladen, *fragilissima* Sladen, *heroina* Sladen, *dimorpha* Sladen, *remex* Sladen, *tuberculata* Sladen. *F. bracteata* Sladen is a synonym of *elegans*, according to Professor Verrill.

FREYELLASTER SPATULIFER Fisher.

Plate 144, fig. 1; plate 154, fig. 3; plate 155, figs. 1, 1*a–h*.

Freyella spatulifera Fisher, 1916*b*, p. 34.
Freyellaster spatulifer Fisher, 1918, p. 104.

Diagnosis.—Rays 14. Genital region of ray short, slightly swollen, the spinelets concentrated in transverse parallel bands, about 30 in number, as a rule 1 opposite each lateral spine and 1 in the interval between; lateral spines opposite every adambulacral beyond the eighth, long and slender. Adambulacral armature: one furrow spinelet at each end of plate, and a second longer one above the aboral spinelet; 1 large suboral spine, which on the first 10 plates is conspicuously broadened and spatulate at tip. Mouth spines, 2 at distal furrow corner of plate and 3 on actinosomial margin, 1 heavy sublanceolate suboral spine, frequently terminating in 2 points. R=

135+mm., r=9 mm.; breadth of ray at base, 4.5 mm.; length of genital region, 30–35 mm.

Description.—Disk fairly large with a beveled margin; disk plates not distinguishable; spinelets delicate, sharp, but invested in a sheath which causes them to appear terete and blunt. They are mostly solitary—that is, are not in groups—and form an evenly spaced, uniform, delicate nap, free from pedicellariae. The spinelets on the margin of disk are a little longer than those at or near the center.

Genital region of ray relatively short, slightly swollen, the spinelets in clusters of 2 to about 6 per plate. On all but the basal fourth of the genital region there are low, transverse, parallel ridges, spaced about 1 mm. apart, formed of very slightly elevated plates bearing most of the short, tapering, sharp spinelets. The spinelets have the appearance of being collected into these transverse bands, while the interspaces have very few spinelets yet there is no regularity in the arrangement of the spinelets on the plates. They may form clusters or short series, oriented obliquely, longitudinally, or transversely with reference to the main axis of ray. These transverse bands of spines resemble somewhat the costae of *Brisinga*, but are much less prominent.

A slender acicular spine, arising from a convex lateral plate fused to the side of every adambulacral plate (usually a little aborad of the middle), beginning with the eighth, increases in length until equal to about 6 or 7 adambulacral plates (at a short distance beyond end of genital region).

Beyond the genital region or area of abactinal plating the integument is excessively thin, so that the underlying ambulacral ridge is clearly visible, and it is crossed at each lateral spine by an inconspicuous band of pedicellariae, usually only with difficulty discernible on the middorsal area.

Adambulacral armature: one furrow spine at each end of the plate, and a little shorter than the midventral length of the plate; above the aboral spinelet, a slender but yet stouter and longer spinule, about 1.6 plates in length, measured along the midactinal line. These 3 spinelets bear at the tip a group of slender-jawed, major pedicellariae. On the actinal surface is a prominent subambulacral spine, which, on the first 10 plates is conspicuously spatulate, gradually lengthening from about the fourth, and narrowing at the tip from the sixth to eighth plates. The broad tip is sometimes flat, sometimes scoop-shaped, sometimes grooved, while the truncated end has often two or three knobs. The knobs become more evident beyond the eighth plate, most of the spines being practically bicapitate. The thirteenth, fourteenth, and fifteenth are very long, slender, and tapering, with either a capitate or a bicapitate tip, while beyond the thirteenth to fifteenth (according to the ray), the spines lose the capitate tip and become pointed. The broadly spatulate spines are about 3 plates in length (3.0 to 4.5 mm.); the pointed acicular ones just beyond the modified subambulacrals are a little over 4 plates in length (7 mm.), the plates themselves becoming gradually longer, as is evident from the above measurements. The subambulacral spines are invested in sheaths bearing both major and minor pedicellariae, while on the lateral spines only the minute minor pedicellariae seem to be present.

Mouth plates each with 3 short spinelets on the actinostomial margin and 2 on the distal furrow corner. Suboral spine about as long as the first subambulacral spine, with a sublanceolate slightly flattened tip, which is grooved lengthwise and frequently ends in 2 distinct, sharp points. The oral and suboral spines are heavily armed with major pedicellariae.

Madreporic body small, but on the external side of a prominent protuberance, the adcentral side of which is spiny.

Gonads and first adambulacral plates as in generic diagnosis.

Type.—Cat. No. 36747, U.S.N.M.

Type-locality.—Station 5668 (lat. 2° 29′ 30″ S.; long. 118° 43′ E.), Macassar Strait, off Mamuju Island, west coast of Celebes, 901 fathoms, gray mud; bottom temperature, 38.2° F.; 1 specimen.

Remarks.—This species has much broader proximal subambulacral spines than any other known species. It differs from *F. echinata* Sladen (if this is indeed a true *Freyellaster*) in lacking the conspicuous abactinal spines. *F. scalaris* (A. H. Clark) has even more conspicuous abactinal spines on the rays than has *echinata.*

BIBLIOGRAPHY.

Alcock, A. (See also Wood-Mason and Alcock.)

1893*a*. Natural History Notes from H. M. Indian Marine Survey Steamer *Investigator*, Commander C. F. Oldham, R. N., commanding.—Series 2, No. 7. An Account of the Collection of Deep-Sea Asteroidea. Ann. and Mag. Nat. Hist., ser. 6, vol. 9, pp. 73–121, pls. 4, 5, 6.

1893*b*. Natural History Notes from H. M. Indian Survey Steamer *Investigator*, Commander C. F. Oldham, R. N., commanding. Series 2, No. 9. An Account of the Deep-Sea Collection made during the season of 1892–93. Journ. Asiat. Soc. Bengal, vol. 62, pt. 2, No. 4, pp. 171–173.

1894. Illustrations of the Zoology of the Royal Indian Marine Surveying Steamer *Investigator*. Echinoderma, pt. 1, pls. 1–3. Calcutta, 4to.

1895. Same, pt. 2, pls. 4 and 5.

Bedford, F. P.

1900. On the Echinoderms from Singapore and Malacca. Proc. Zool. Soc. London, pp. 271–299, pls. 21–24.

Bell, F. Jeffrey.

1883. Descriptions of Two New Species of Asteroidea in the Collection of the British Museum. Ann. and Mag. Nat. Hist., ser. 5, vol. 12, pp. 333–335.

1884*a*. Contributions to the Systematic Arrangement of the Asteroidea, II. The Species of Oreaster. Proc. Zool. Soc. London, pp. 57–87.

1884*b*. Echinodermata. Report on the Zoological Collections made in the Indo-Pacific Ocean during the voyage of H. M. S. *Alert*, 1881–82, pp. 117–177, 509–512.

1887. Report on a Collection of Echinodermata from the Andaman Islands. Proc. Zool. Soc. London, pp. 139–145 (January).

1894. On the Echinoderms collected during the voyage of H. M. S. *Penguin* and by H. M. S. *Egeria*, when surveying Macclesfield Bank. Proc. Zool. Soc. London, pp. 392–413.

1899. Report on the Echinoderms (other than Holothurians) collected by Dr. Willey. With figures on plate 17 and one figure in the text. Zoological results based on material from New Britain, New Guinea, Loyalty Islands, and elsewhere, collected during the years 1895, 1896, and 1897 by Arthur Willey. Pt. 2, pp. 133–140.

Brown, R. N. R.

1910. Echinoidea and Asteroidea from the Mergui Archipelago and Moskos Islands, Lower Burma. Proc. Royal Phys. Soc. Edinburgh, vol. 18, pp. 21–35. Feb. 17.

Clark, H. L.

1908. Some Japanese and East Indian Echinoderms. Bull. Mus. Comp. Zoöl., vol. 51, No. 11, pp. 279–311.

Clark, H. L.—Continued.

1909. Notes on some Australian and Indo-Pacific Echinoderms. Bull. Mus. Comp. Zoöl., vol. 52, No. 7, p. 110.

1915. The Echinoderms of the West Australian Museum. Records W. A. Museum, vol. 1, pp. 132–173, pls. 17–24 (Asteroidea, pp. 135–151, pls. 17–21).

1916. Report on the Sea-Lilies, Starfishes, Brittle-Stars and Sea-Urchins obtained by the F. I. S. *Endeavour* on the coasts of Queensland, New South Wales, Tasmania, Victoria, South Australia, and Western Australia, 123 pp., 44 plates. Sydney, June 2.

Döderlein, L.

1896. Bericht über die von Herrn Professor Semon bei Amboina und Thursday Island gesammelten Asteroidea. Zool. Forschungsreisen in Australien u. d. Malayischen Archipel., vol. 5, pp. 301–326, pls. 18–22.

1917. Die Asteriden der Siboga-Expedition. 1. Die Gattung Astropecten und Ihre Stammesgeschichte. Monographie XLVI*a* aus: Uitkomisten op Zoologisch, Botanisch, Oceanographisch en Geologisch Gebied verzameld in Nederlandsch Oost-Indië 1899–1900 an boord H. M. Siboga onder commando van Lieutenant ter zee 1e kl. G. F. Tydeman. Uitgegeven door Dr. Max Weber. Leiden. 191 pp. 17 plates. (July.)

Dujardin, F., and Hupé, H.

1862. Histoire naturelle des zoophytes échinodermes, etc., p. 627, 10 pls.

Fisher, Walter K.

1906. The Starfishes of the Hawaiian Islands. U. S. Fish Comm. Bull. for 1903, pt. 3, pp. 987–1130, pls. 1–49, June 30, 1906.

1908. Necessary Changes in the Nomenclature of Starfishes, Smiths. Misc. Coll. (Quart.), vol. 52 (No. 1799), pp. 87–93, May 27. Also Zool. Anz., vol. 32, pp. 356–359, August 18.

1910. New Genera of Starfishes. Ann. and Mag. Nat. Hist., ser. 8, vol. 5, Feb., pp. 171–173.

1911a. The Genus Blakiaster Perrier. Bull. Mus. Comp. Zoöl., vol. 54, No. 4, pp. 161–164, pls. 1, 2.

1911*b*. Hyalinothrix, a New Genus of Starfishes from the Hawaiian Islands. Proc. U. S. Nat. Mus., vol. 39, pp. 659–664, pls. 69–71. (Mar. 11.)

1911*c*. New Genera of Starfishes from the Philippine Islands (Scientific Results of the Philippine Cruise of the Fisheries Steamer *Albatross*, 1907–1910, No. 10). Proc. U. S. Nat. Mus., vol. 40, pp. 415–427. (May 17.)

1911*d*. Asteroidea of the North Pacific and Adjacent Waters. pt. 1. Phanerozonia and Spinulosa. U. S. Nat. Mus. Bull. 76, vi+419 pp., 122 pls. (June 30.)

1913*a*. Four New Genera and Fifty-eight New Species of Starfishes from the Philippine Islands, Celebes, and the Moluccas. Proc. U. S. Nat. Mus., vol. 43, pp. 599–648. (Feb. 5.)

1913*b*. A new species of Echinaster, with a note on the name Othilia. Zoolog. Anz., vol. 42, no. 5, pp. 193–196. (July 4.)

1913*c*. New Starfishes from the Philippine Islands, Celebes, and the Moluccas. Proc. U. S. Nat. Mus., vol. 46, pp. 201–224. (Sept. 30.)

1916*a*. Notes on the Systematic Position of Certain Genera and Higher Groups of Starfishes. Proc. Biol. Soc. Washington, vol. 29, pp. 1–6. (Jan. 25.)

FISHER, WALTER K.—Continued.

1916*b*. New East Indian Starfishes. Proc. Biol. Soc. Washington, vol. 29, pp. 27–36. (Feb. 24.)

1917*a*. The Asteroid Genus Coronaster. Proc. Biol. Soc. Washington, vol. 30, pp. 23–26. (Feb. 21.)

1917*b*. New Starfishes from the Philippines and Celebes. Proc. Biol. Soc. Washington, vol. 30, pp. 89–94. (May 23.)

1917*c*. Trophodiscus, a new Sea Star from Kamchatka. Proc. U. S. Nat. Mus., vol. 52, pp. 367–371, pls. 28–30. (March 7).

1917*d*. Notes on Asteroidea. Ann. and Mag. Nat Hist., ser. 8, vol. 20, pp. 166–172. (August.)

1917*e*. A New Genus and Subgenus of East Indian Sea Stars. Ann. and Mag. Nat. Hist., ser. 8, vol. 20, pp. 172, 173. (August.)

1917*f*. New Genera and Species of Brisingidae. Ann. and Mag. Nat. Hist., ser. 8, vol. 20, pp. 418–431. (December.)

1918. Notes on Asteroidea.—II. Ann. and Mag. Nat. Hist., ser. 9, vol. 2, pp. 103–111, pl. 13. (July.)

GOTO, SEITARO.

1914. A Descriptive Monograph of Japanese Asteroidea. I. Archasteridae, Benthopectinidae, Porcellanasteridae, Astropectinidae, Luidiidae, Pentagonasteridae, Oreasteridae, Gymnasteridae, Asterinidae. Journ. Coll. Science, Imperial Univ. Tokyo, vol. 29, art. 1, pp. 1–808, 19 pls.

GRAY, J. E.

1840. A Synopsis of the Genera and Species of the Class Hypostoma (Asterias, Linnaeus). Ann. and Mag. Nat. Hist., vol. 6, pp. 175–184 (November), 275–290 (December).

1847*a*. Descriptions of Some New Genera and Species of Asteriadae. Ann. and Mag. Nat. Hist., vol. 20, pp. 193–204; also Proc. Zool. Soc. London, 1847, pp. 73–83.

1866. Synopsis of the Species of Starfish in the British Museum. 18 pp., 16 pls.

HARTLAUB, C.

1892. Ueber die Arten und den Skelettbau von Culcita. Notes from the Leyden Museum, vol. 14, pp. 65–118, pl. 2 (April).

KOEHLER, R.

1895. Catalog raisonné des échinodermes recueillis par M. Korotnev aux îles de la Sonde. Mém. soc. zool. France, pp. 374–423.

1909. An account of the Deep-sea Asteroidea Collected by the Royal Indian Marine Survey Ship *Investigator*. Astéries recueillis par l'Investigator dans l'Océan Indien. 1. Les Astéries de Mer profonde. 143 pp., 13 pls.

1910*a*. An Account of the Shallow-water Asteroidea. Echinoderma of the Indian Museum, pt. 6. Asteroidea (2). 191 pp. 20. pls. (June).

1910*b*. Astéries et Ophiures des îles Aru et Kei. Abhandl. Senckenberg. Naturf. Gesell., vol. 33, pp. 265–295, 3 pls.

LAMARCK, J. B. P. A. DE.

1816. Histoire naturelle des animaux sans vertébres, etc., vol. 2, pp. 547–568.

LORIOL, P. DE.

1885. Catalogue raisonné des échinodermes recueillis par M. V. de Robillard à l'île de Maurice. 2. Stellérides. Mém. soc. d. phys. et d'hist. natur. Genève, vol. 29, no. 4, 84 pp., pls. 7–22.

Loriol, P. de.—Continued.

1891. Notes pour servir à l'étude des échinodermes. Mém. soc. d. phys. et d'hist. natur. Genève, vol. supplém., 1890. no. 8, 21 pp., 3 pls.

1893. Échinodermes de la Baie d'Amboine. Rev. suis zool. et Ann. mus. hist, natur. Genève, vol. 33, pt. 2, no. 1, 34 pp., 3 pls.

1899. Notes pour servir à l'étude des échinodermes. Mém. soc. phys. et hist. natur. Genève, vol. 33, pt. 2, no. 1, 34 pp., 3 pls.

Ludwig, Hubert.

1897. Die Seesterne des Mittlemeeres. Fauna and Flora des Golfes von Neapel, vol. 24, pp. 1–487, 12 pls.

1903. Seesterne. Résultats du voyage du S. Y. *Belgica* en 1897–1898–1899 sous le commandement de A. de Gerlache de Gomery. 72 pp., 7 pls.

1905. Asteroidea, in: Reports on an Exploration off the West Coasts of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer *Albatross*, during 1891, etc. Mem. Mus. Comp. Zoöl., vol. 32, 292 pp., 35 plates, 1 chart. (July 17.)

1910. Notomyota, eine neue Ordnung der Seesterne. Sitzungsber. k. preus. Akad. Wiss., vol. 23, pp. 435–466. (May 12.)

1912. Über die J. E. Gray'schen Gattungen Pentagonaster und Tosia. Zool. Jahrb., Suppl. 15, vol. 1, pp. 1–44.

Lütken, C.

1864. Kritiske Bemaerkninger om forsjellige Søstjerne (Asteriderne), med Beskrivelse af nogle nye Arter. Vidensk. Meddel. fra d. natur. hist. Foren. i Kjøbenhavn, pp. 123–169.

1869. Choriaster granulatus, eine neue Gattung aus der Familie der Asteriden. Catalog 4 des Museum Godeffroy, Hamburg.

1871. Fortsatte kritiske og beskrivende Bidrag til Kundskab om Søstjerne (Asteriderne). Vidensk. Meddel. pp. 227–304, 1 pl.

Martens, E. von.

1865. Ueber ostasiatische Echinodermen, 1. Archiv. f. Naturgesch., pp. 345–360.

1866. The same, 2. Archiv f. Naturgesch., pp. 57–88.

1867. The same, 4. Archiv f. Naturgesch., pp. 106–119.

Möbius, K.

1859. Neue Seesterne des Hamburger und Kieler Museums. 14 pp., 4 pls.

Müller, J., and Troschel, F. H.

1840*a*. Monatsber. k. preuss. Akad. Wiss., p. 102. (April.) Not seen; title of article unknown to me.

1840*b*. Ueber die Gattungen der Asterien. Archiv f. Naturgesch., 6 Jahrg., vol. 1, pp. 318–326. (September.)

1842. System der Asteriden. xx pp.+134 pp., 12 pls.

Perrier, E.

1869. Recherches sur les pédicellaires et les ambulacres des Astéries et des Oursins, pp. 5–110, pls. 1–2.

1875. Révision de la collection de stellérides du museum d'histoire naturelle de Paris, 384 pp. My copy is a separate, dated 1875, and with special title page; published also 1876, Archiv. zool, expér. et gén., vol. 5, pp. 1–104 and 209–304.

1881. Description sommaire des espèces nouvelles d'Astéries. Bull. Mus. Comp. Zool., vol. 9, no. 1, pp. 1–31. (June 25.)

PERRIER, E.—Continued.

1884. Mémoire sur les Étoiles de mer recueillis dans la mer des Antilles et le Golfe du Mexique durant les expéditions de dragage faites sous la direction de M. Alexander Agassiz. Nouv. arch. d. mus. d'hist. nat., sér. 2, vol. 6, pp. 127–216, pls. 1–9.

1891. Échinodermes de la mission scientifique du Cap Horn. 1. Stellérides. Mission scientifique Cap Horn, Zoologie, vol. 6, 198 pp., 13 pls.

1894. Expéditions scientifiques du *Travailleur* et du *Talisman*, Èchinodermes, 432 pp., 36 pls.

PFEFFER, G.

1900. Echinodermen von Ternate. Echiniden, Asteriden, Ophiuriden u. Comatuliden. Ergebn. zool. Forschungsreise in d. Molukken u. Borneo, W. Kükenthal. Abh. Senckenberg. Ges., 25, pp. 81–86.

SIMPSON, J. J., and BROWN, R. N. R.

1910. Asteroidea of Portugese East Africa, etc. Proc. Roy. Phys. Soc. Edinburgh, vol. 18, pp. 45–60. (Feb. 18.)

SLADEN, W. P.

1879. On the Asteroidea and Echinoidea of the Korean Seas. Journ. Linn Soc. London, vol. 14, pp. 424–445, pl. 8.

1882. The Asteroidea of H. M. S. *Challenger* Expedition, pt. 1. Journ. Linn. Soc. London, vol. 16, Mar. 8, 1882, pp. 189–246.

1883a. The Asteroidea of H. M. S. *Challenger* Expedition, pt. 2. Journ. Linn. Soc. London, Zool., vol. 17, pp. 214–269.

1883*b*. Description of Mimaster, a genus of Asteroidea from the Faeröe Channel. Trans. Roy. Soc. Edinburgh, vol. 30, pt. 2, pp. 579–584, pl. 34.

1885. Report of the Scientific Results of the Voyage of H. M. S. *Challenger*. Narrative of the Cruise, pt. 2.

1889. Report on the Asteroidea collected by H. M. S. *Challenger*. Zoology, vol. 30, xlii+893 pp., 117 pls., 1 chart.

SLUITER, C. P.

1889. Die Evertebraten aus der Sammlung des Königl. naturwissenschaftlichen Vereins in Niederländisch Indien in Batavia. Naturk. Tijdschrift voor Niederländisch-Indië, ser. 8, deel 9, pp. 297–313.

1895. Die Asteriden Sammlung des Museums zu Amsterdam. Bijd. tot de Dierk., Koninkl. Zoöl. Genoot. "Natura Artis Magistra," Amsterdam, Afl. 17, pp. 51–64.

STUDER, T.

1883. Sitzungsber. naturforsch. Freunde in Berlin, p. 129. (Oct. 16.)

1884. Verzeichnis der während der Reise S. M. S. *Gazelle* um die Erde 1874–1876 gesammelten Asteriden und Euryaliden. Abhandl. d. k. preuss. Akad. Wiss. Berlin v. J. 1884, pp. 3–64, 5 pls.

VERRILL, A. E.

1899. Revision of Certain Genera and Species of Starfishes with Descriptions of New Forms. Trans. Conn. Acad. Arts and Sciences, vol. 10, pp. 145–234, 8 pls.

1913. Revision of the Genera of Starfishes of the Subfamily Asterininae. Amer. Journ. Sci., vol. 35, pp. 477–485.

VERRILL, A. E.—Continued.

1914*a*. Monograph of the Shallow-water Starfishes of the North Pacific Coast from the Arctic Ocean to California. Smithsonian Institution. Harriman Alaska series, vol. 14, 2 parts, xii+408 pp., 110 pls.

1914*b*. Revision of some Genera and Species of Starfishes, with Descriptions of a few new Genera. Ann. and Mag. Nat. Hist., ser. 8, vol. 14, pp. 13–22. (July.)

1915. Report on the Starfishes of the West Indies, Florida, and Brazil, including those obtained by Bahama Expedition from the University of Iowa in 1893. Bull. State Univ. Iowa, vol. 7, No. 1, 232 pp. 29 pls.

VIGUIER, C.

1878. Anatomie comparée du squelette des Stellérides. Arch. zool. expér. et gén., vol. 7, pp. 33–250, pls. 5–16.

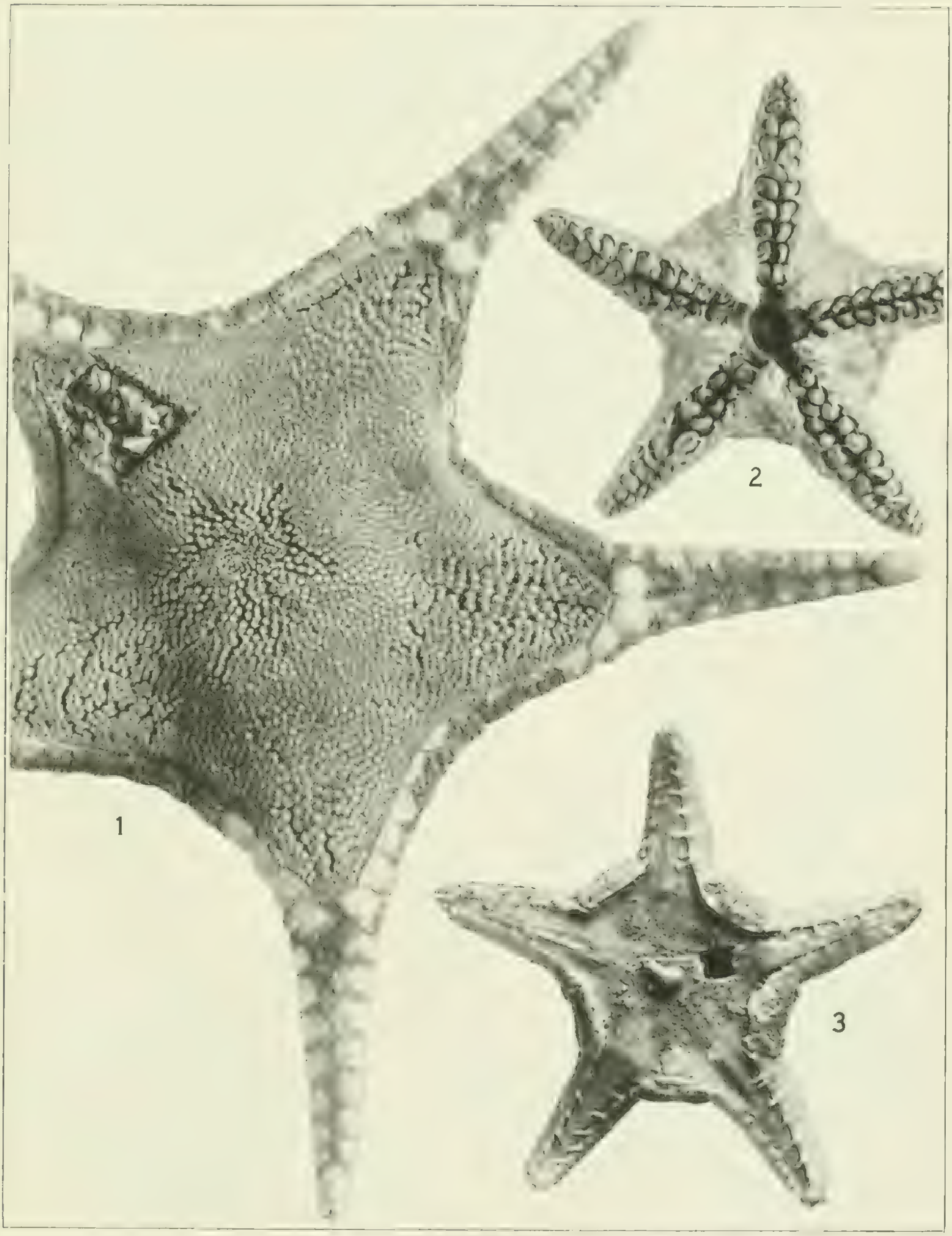
WOOD-MASON, J., and ALCOCK, A.

1891. Natural History Notes from H. M. Indian Marine Survey Steamer *Investigator*, etc., ser. 2, No. 1. On the Results of Deep-sea Dredging during the season 1890–91. Ann. and Mag. Nat. Hist., ser. 6, vol. 8, pp. 427–440.

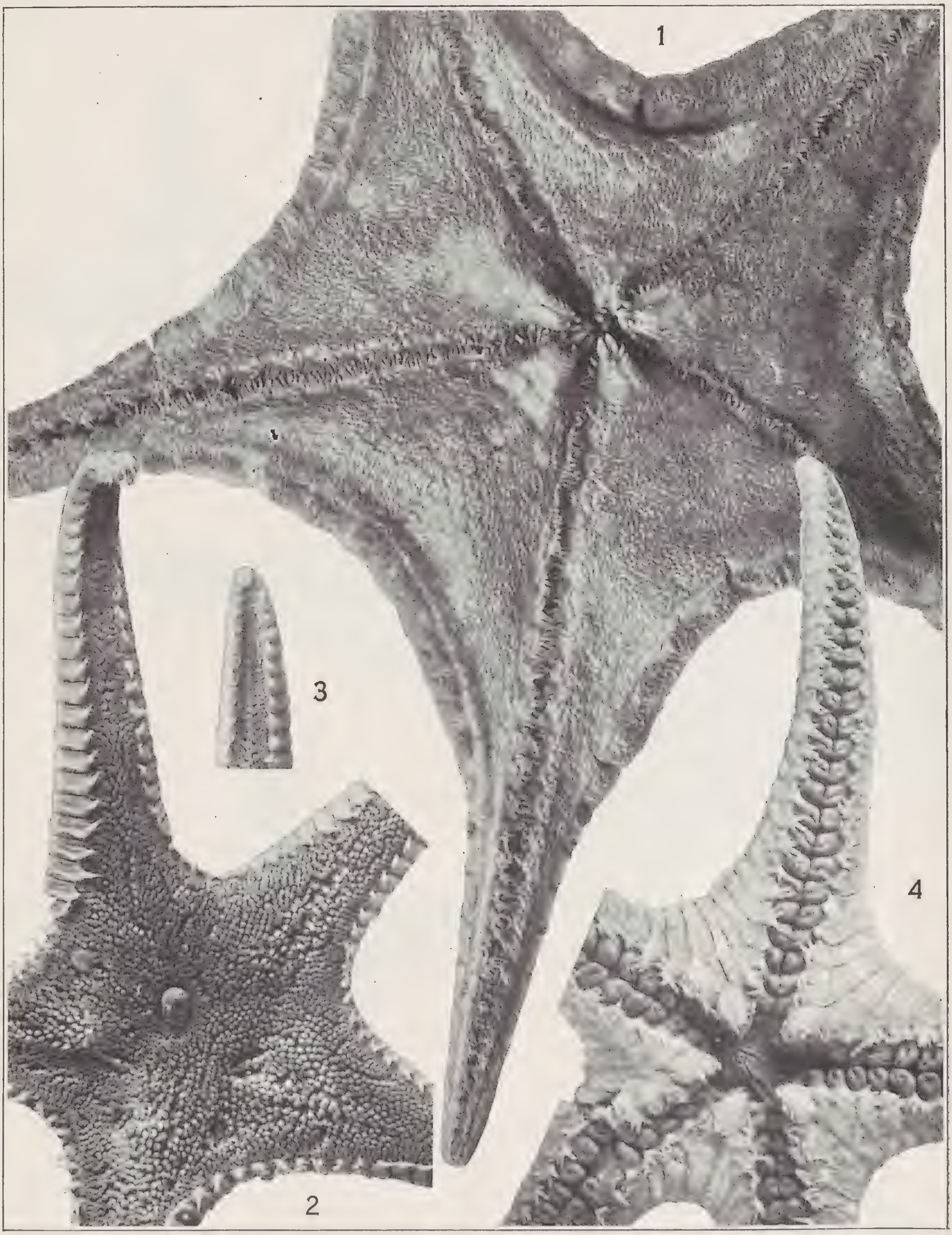
EXPLANATION OF PLATES.

PLATE 1.

FIG. 1. *Benthogenia cribellosa;* actinal surface of type, enlarged, p. 39.
2. *Sidonaster psilonotus;* actinal view of type, enlarged, p. 37.
3. Same; abactinal view of type, enlarged.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



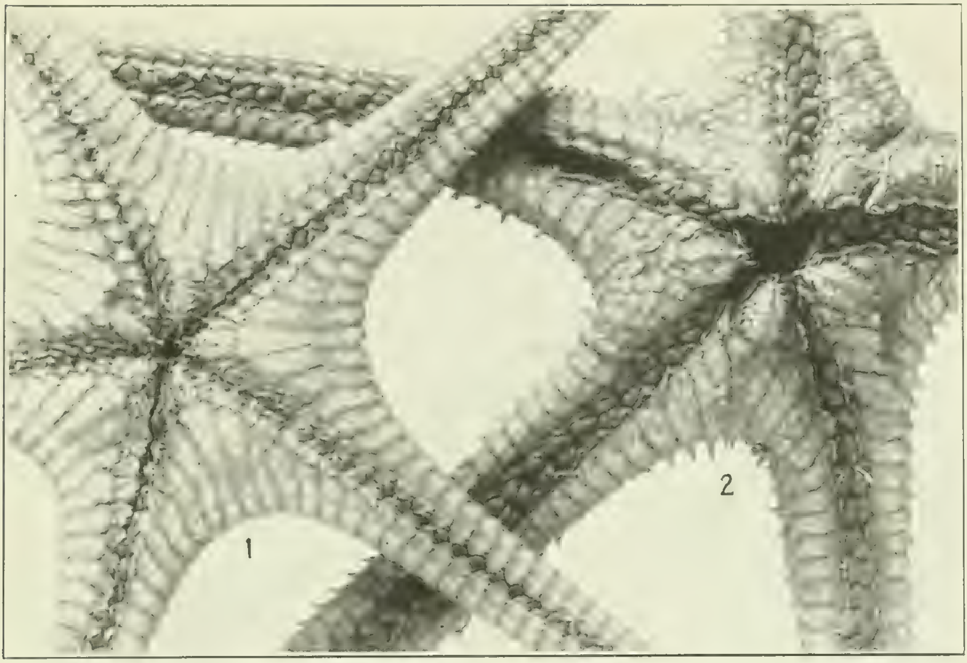
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

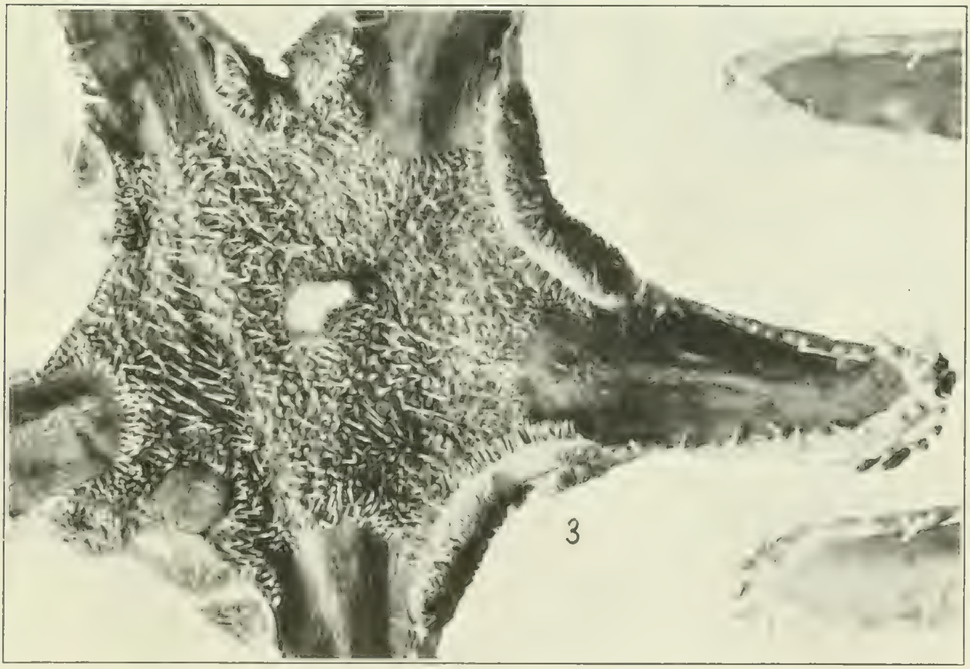
PLATE 2.

FIG. 1. *Benthogenia cribellosa;* actinal surface of type, enlarged, p. 39.
2. *Ctenodiscus orientalis;* abactinal aspect of type, p. 44.
3. Same; end of ray.
4. Same; actinal surface of type.

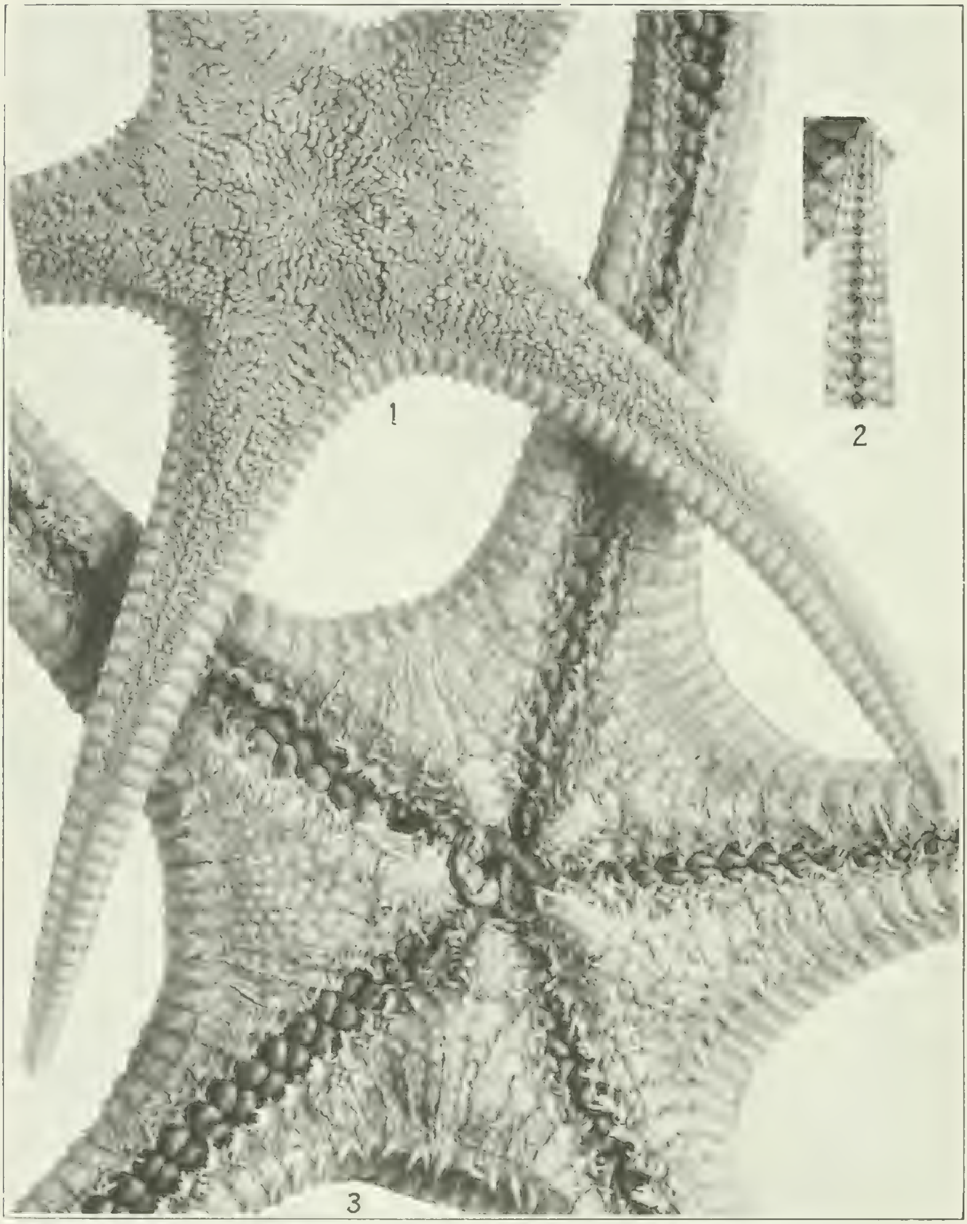
Plate 3.

Fig. 1. *Prionaster analogus;* actinal aspect of type, p. 50.
2. *Prionaster gracilis;* actinal surface of type, p. 55.
3. *Sidonaster vaneyi;* abactinal surface enlarged, and the ends of 2 rays,
550





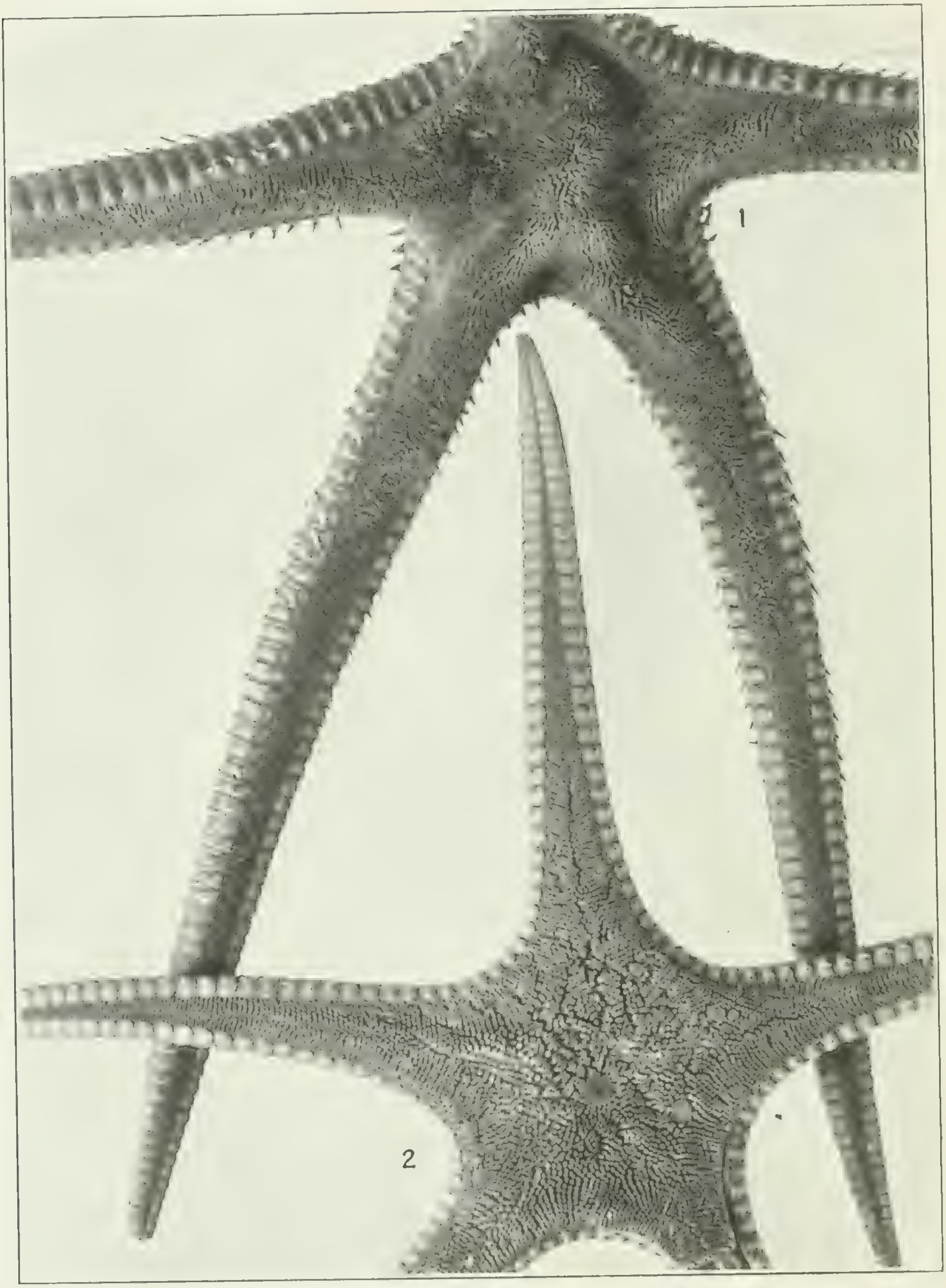
Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 4.

FIG. 1. *Goniopecten asiaticus;* abactinal aspect of type, p. 47.
2. *Prionaster analogus;* tip of ray, actinal view, p. 50.
3. *Prionaster megaloplax;* actinal surface of type, p. 56.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 6.

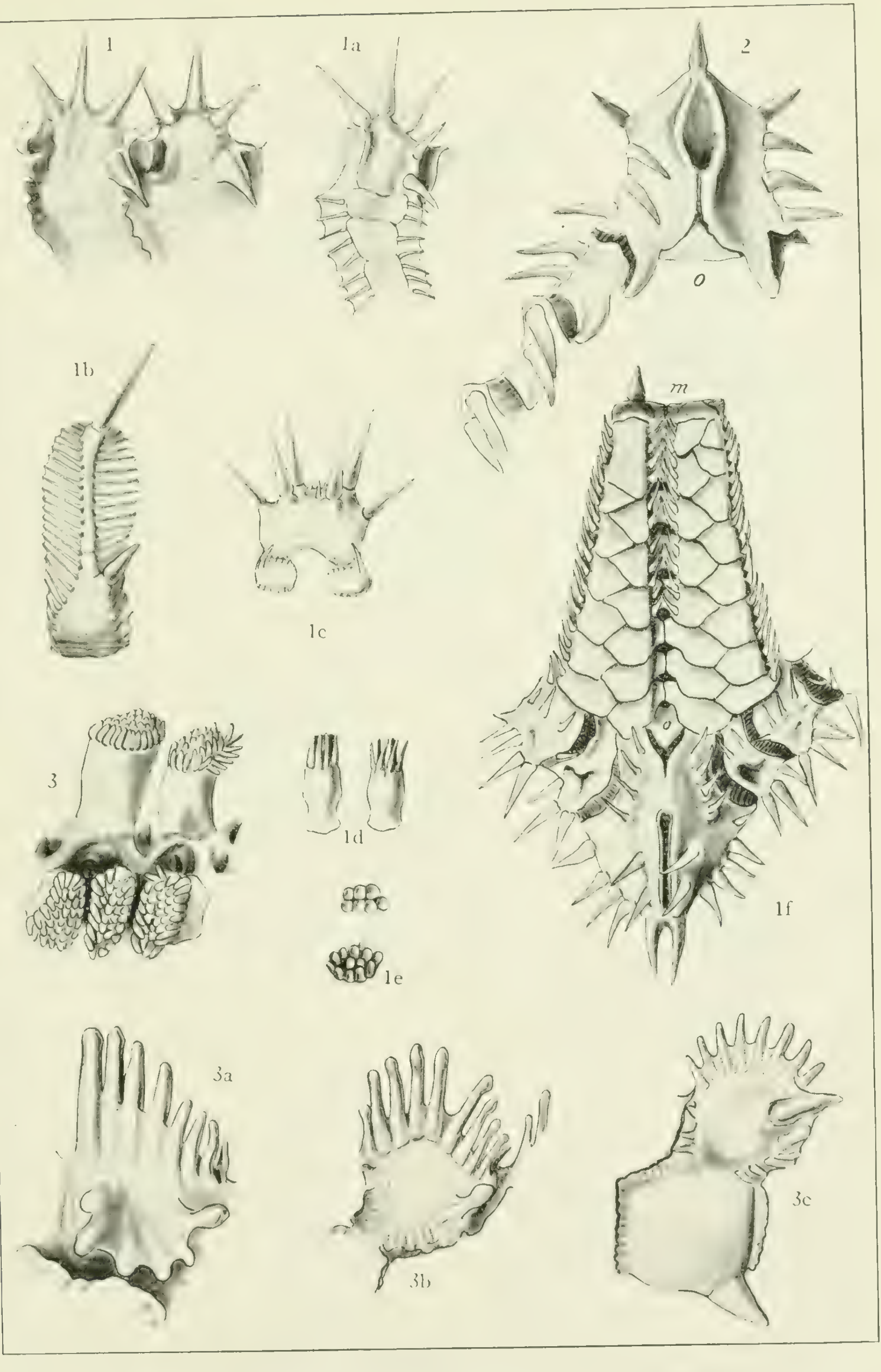
FIG. 1. *Prionaster gracilis;* abactinal view of type, p. 55.
2. *Prionaster analogus;* abactinal view of type, p. 50.

Plate 7.

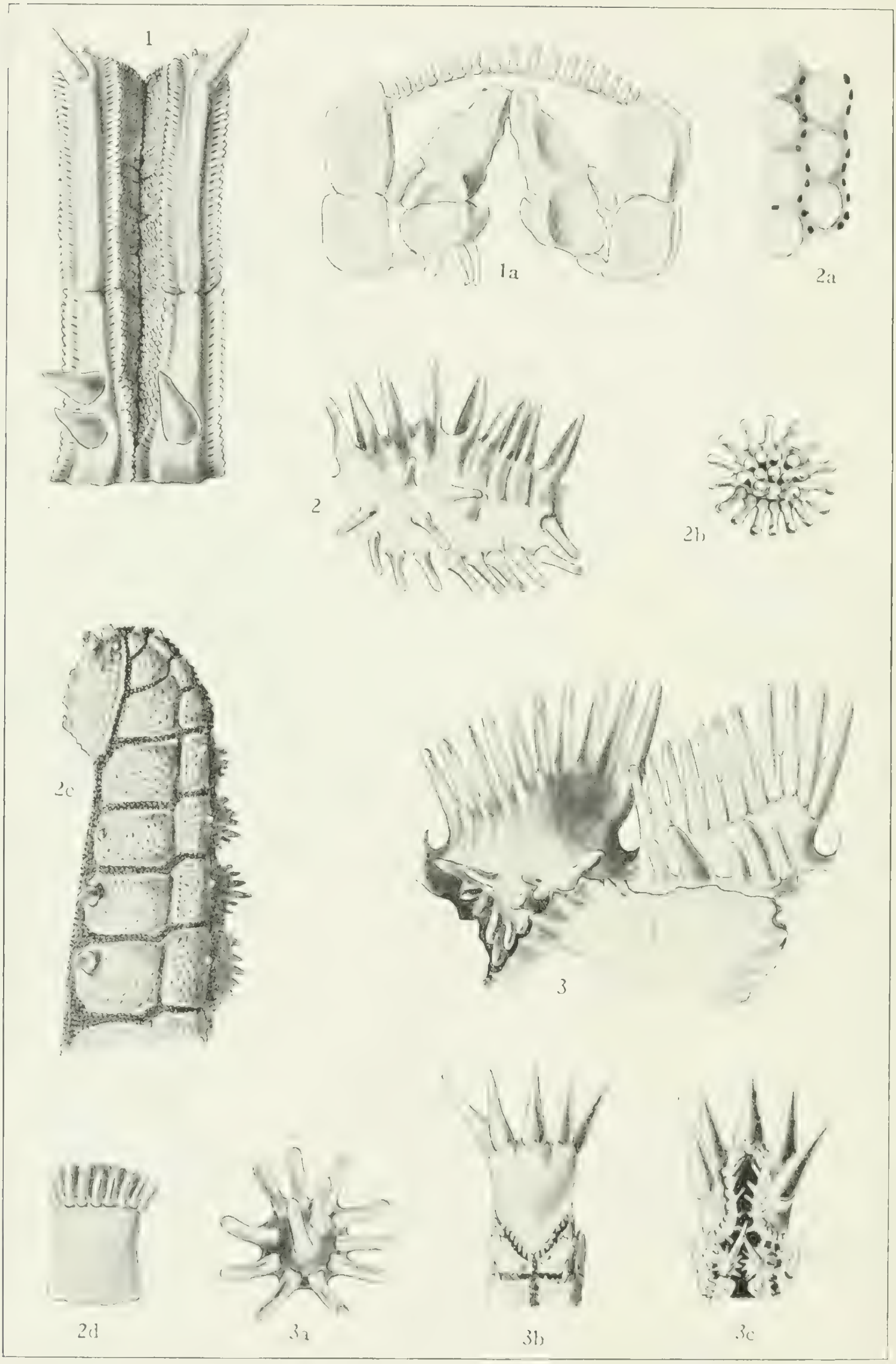
Fig. 1. *Ctenodiscus orientalis;* specimen from station 5527; fifth and sixth adambulacral plates and adjacent intermediate plates, showing the membrane partly shrunken; adoral side of plates to the left, ×6.5. 1*a*. Same; second adambulacral plate, dried, ×6.5. 1*b*. Same; ninth superomarginal and inferomarginal plates showing narrow free surface and broad marginal web. Below the inferomarginal plate 2 actinal intermediate plates are indicated, ×8. 1*c*. Same; terminal plate of specimen from station 5423, ×8. 1*d*. Same; side view of 2 dried paxillae from the proximal portion of radial region, ×8. 1*e*. Same; dorsal view of 2 paxillae from alcoholic specimen. 1*f*. Same; dried specimen, showing mouth, adambulacral, and 2 double series of actinal intermediate plates. From the median fasciole the spinelets have been partly removed to show the articulation of plates. Back of the mouth plates is shown the oral plate or odontophore (*o*). The surface of the adambulacral plates, when the membrane is removed, is irregularly sunken and pitted; *m*, inferomarginal plates; ×6.5. P. 44.

2. *Sidonaster psilonotus;* mouth and adambulacral plates of type; *o*, oral plate or odontophore; ×6.5. P. 37.

3. *Goniopecten asiaticus*, type; paxillae from base of ray, near radial line, showing both dorsal and side views, ×8. 3*a*. Same; sixth adambulacral plate, of which the adoral side is to the left; ×5. 3*b*. Same; eleventh adambulacral plate, ×5. 3*c*. Same; thirty-fourth adambulacral, and thirty-first inferomarginal plates, oriented as in 3*a* and 3*b;* ×5. P. 47.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 8.

FIG. 1. *Goniopecten asiaticus;* interradial cribiform organ of the type, showing also 2 superomarginal and 2 inferomarginal plates with their spines, ×5. 1*a*. Same; a cross-section of ray of type, taken about a third its length from base, to show the relation of plates, and especially the massive marginals. ×2.5. P. 47.

2. *Benthogenia cribellosa;* sixth adambulacral plate of type, the adoral side to left. ×8. 2*a*. Same; abactinal plates. ×5. 2*b*. Same; one of the largest radial paxillae, ×8. 2*c*. Same; end of ray from side showing the terminal plate, dorsal and marginal cribriform organs, ×2.5. The 2 distalmost spines of the terminal plate are each paired; the 3 proximal, shown by scars, are unpaired. 2*d*. Same; a smaller radial paxilla from side, ×12. P. 39.

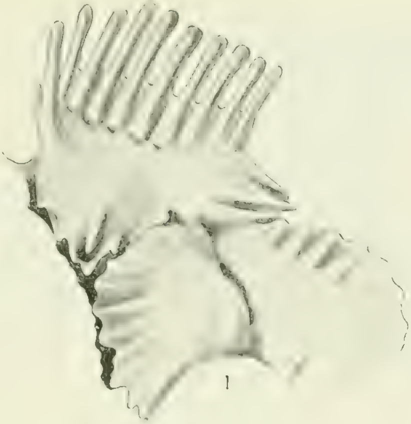
3. *Prionaster analogus;* fifth and sixth adambulacral plates, the adoral side being to the right. The right-hand plate is shown partly dried in order to bring out the form of the furrow spines; ×8. 3*a*. Same; a paxilla from about the middle of major radius, ×16. 3*b*. Same; dorsal view of a terminal plate and 3 adjacent superomarginals of a specimen from station 5565, ×8. 3*c*. Same; ventral view of plate shown in 3*b*; an inferomarginal and 2 adambulacral plates are shown on either side of the furrow; ×8. P. 50.

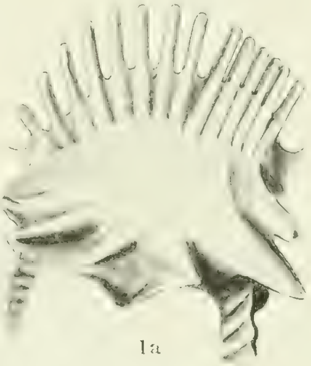
Plate 9.

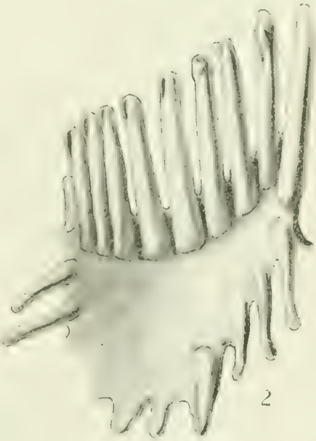
Fig. 1. *Prionaster gracilis;* fourth adambulacral plate of type, ×8. 1*a*. Same; twentieth adambulacral plate of same ray, ×8; in both figures the adoral side of plate is to the left. 1*b*. Same; paxillae from base of ray, ×16. P. 55.

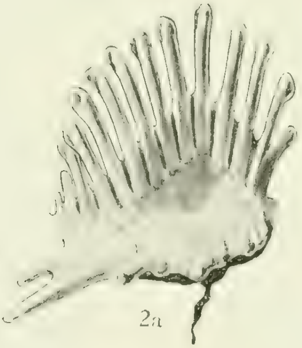
2. *Prionaster megaloplax;* second adambulacral plate of type, ×5. 2*a*. Same; twentieth adambulacral plate of type, ×5; in both figures the adoral side of plate is to the right. The plates are shown partly dried. 2*b*. Same; paxillae from disk, about midway between center and margin, and radial and interradial lines, ×8. P. 56.

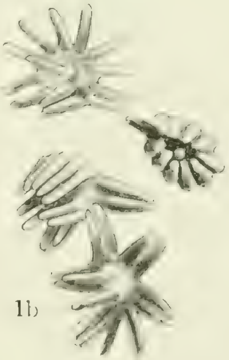
3. *Craspidaster hesperus;* abactinal plates from base of ray; *r–r*, radial line; the dotted line indicates the transverse rows of plates; ×8. P. 60.

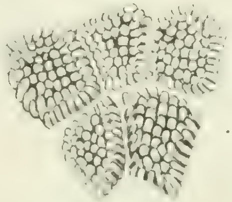

1

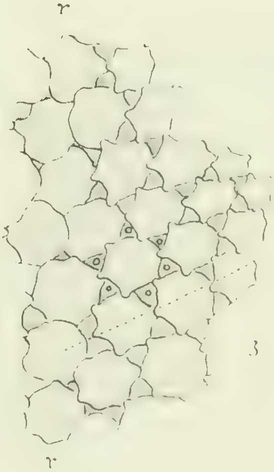

1a


2


2a

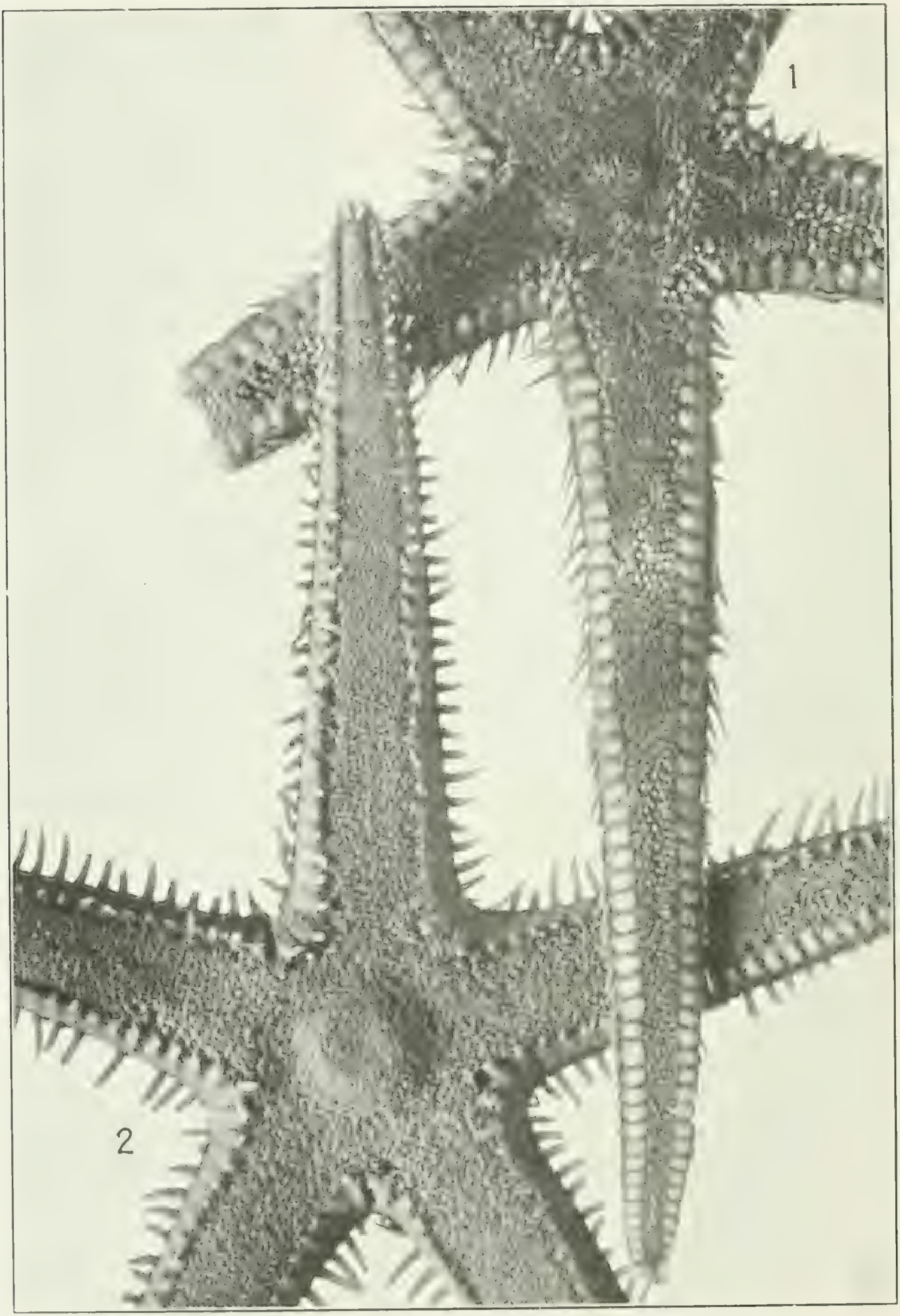

1b


2b



3

STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



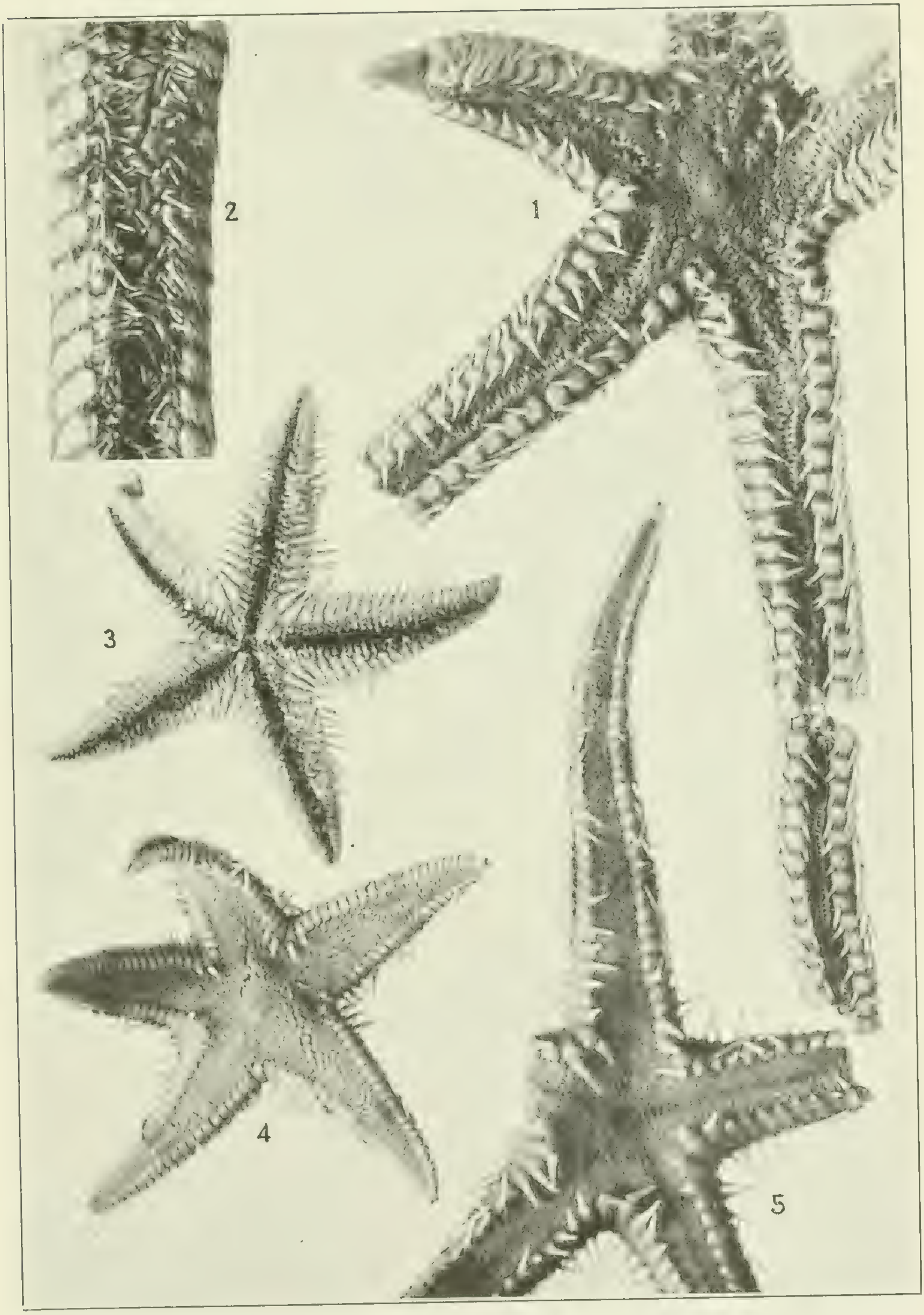
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 10.

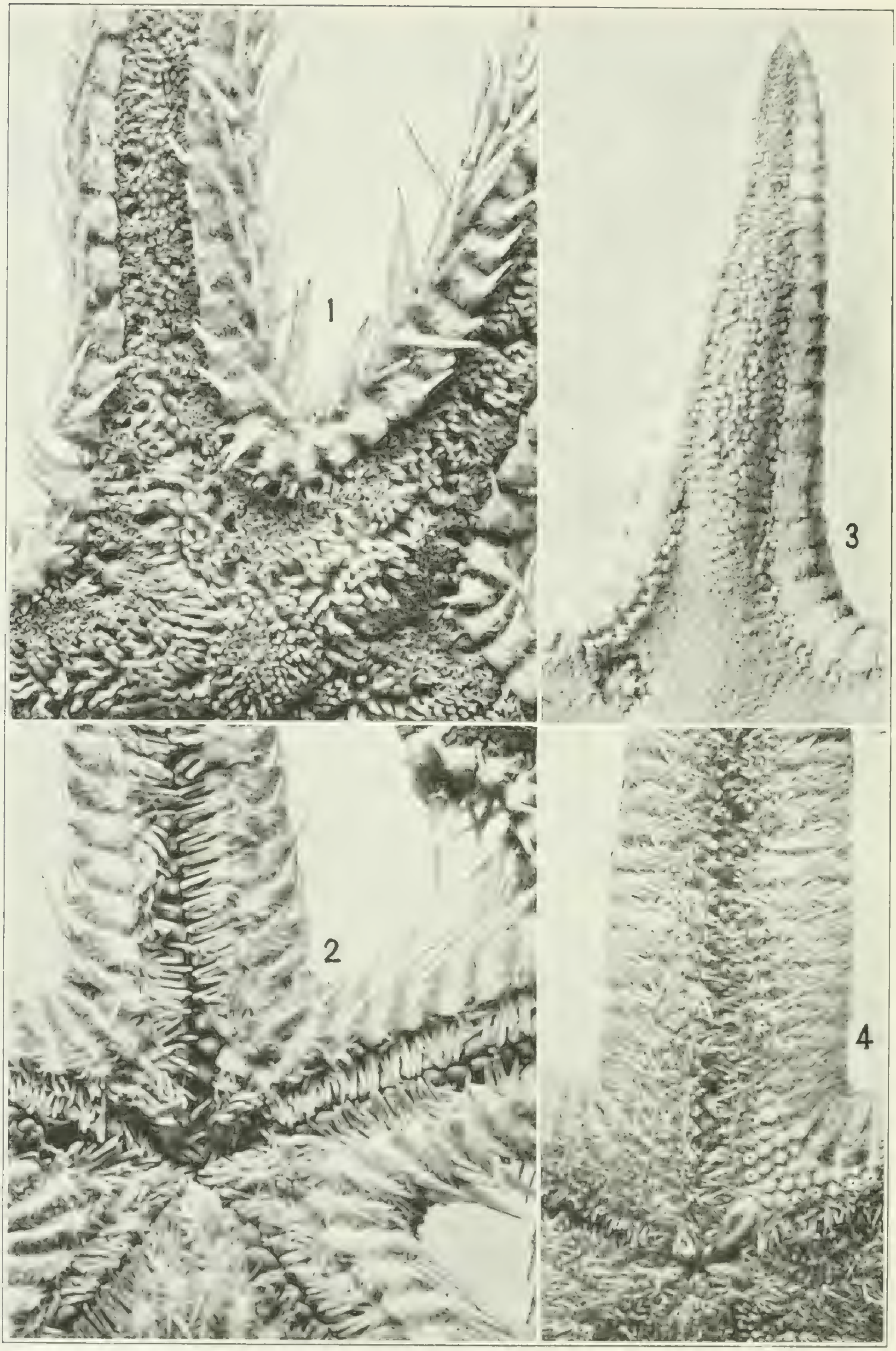
FIG. 1. *Astropecten eucnemis;* actinal surface, enlarged, p. 75.
2. *Astropecten mindanensis;* abactinal surface, enlarged, p. 67.

PLATE 11.

FIG. 1. *Astropecten tenellus;* abactinal aspect, enlarged, p. 84.
2. Same; actinal surface of a portion of ray, enlarged.
3. *Astropecten velitaris;* actinal surface, p. 70.
4. Same; abactinal surface.
5. *Astropecten phragmorus;* abactinal aspect of type, enlarged, p. 65.



Starfishes of the Philippine Seas and Adjacent Waters.



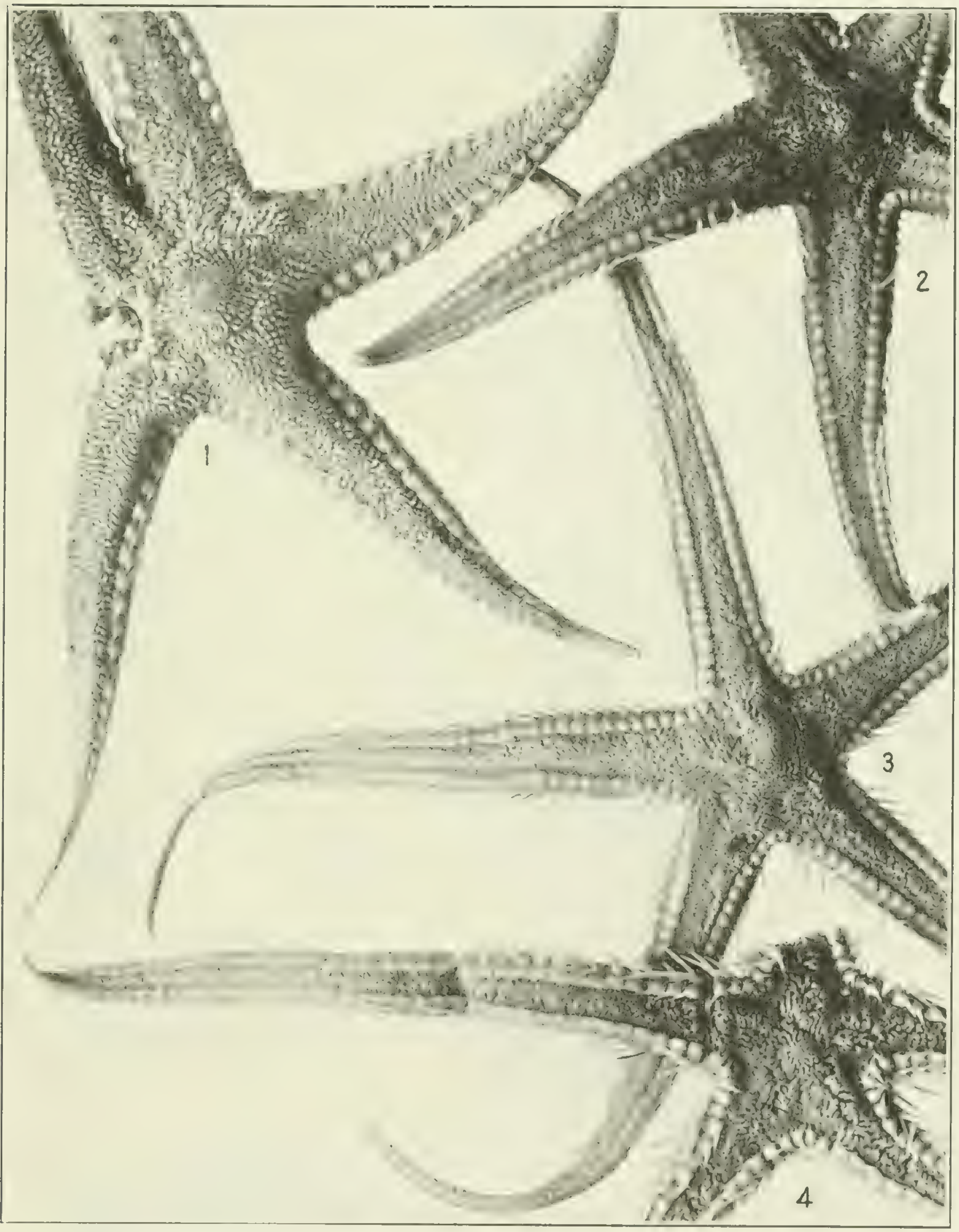
Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 12.

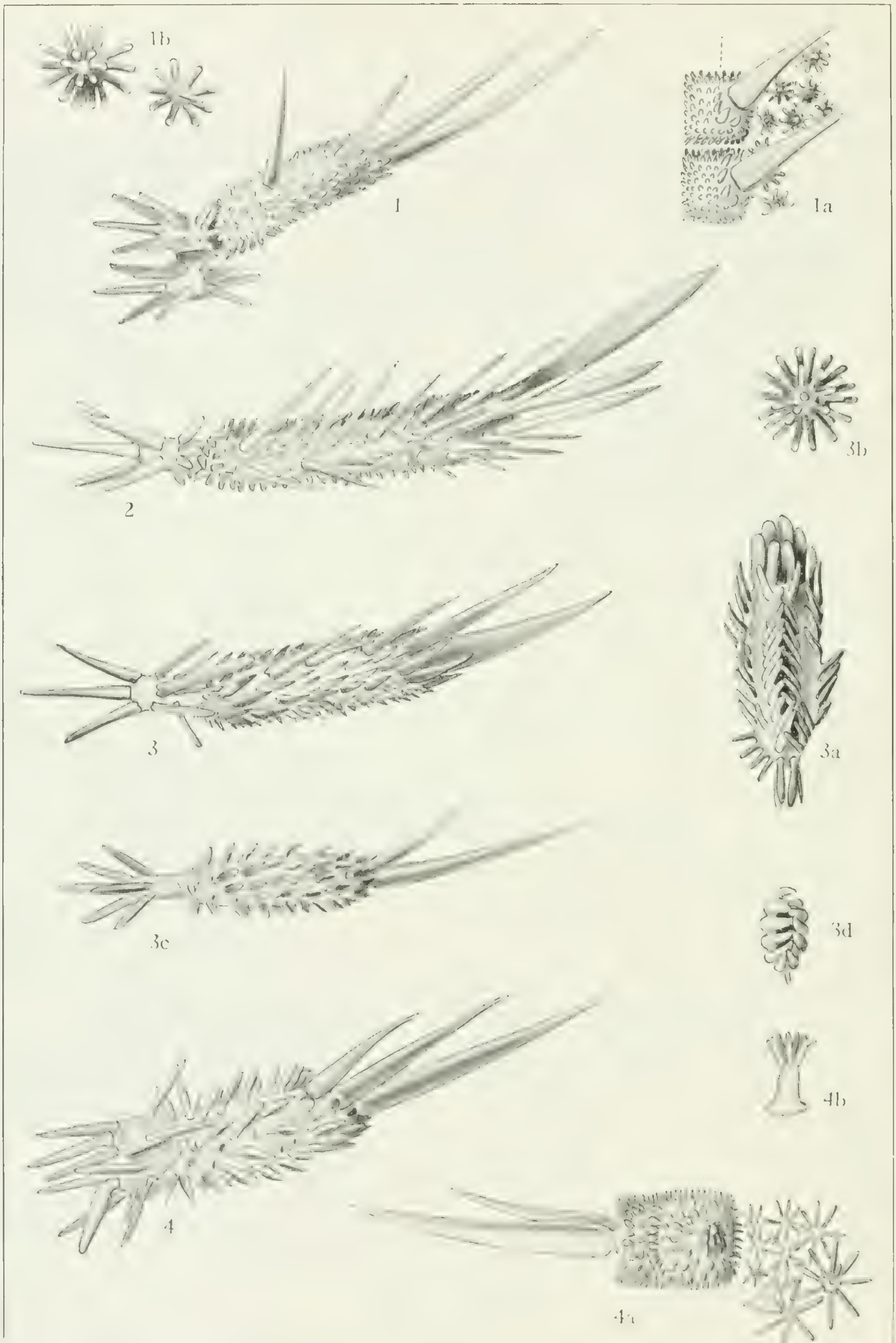
FIG. 1. *Astropecten pedicellaris;* portion of abactinal surface, enlarged, p. 87.
2. *Astropecten luzonicus;* portion of actinal surface, enlarged, p. 82.
3. *Dipsacaster diaphorus;* abactinal aspect of ray, enlarged, p. 152.
4. *Ctenophoraster diploctenius;* actinal view of ray, enlarged, p. 95.

PLATE 13.

FIG. 1. *Persephonaster habrogenys;* abactinal aspect of type, enlarged, p. 131.
2. *Astropecten cremicus;* abactinal view of type, enlarged, p. 79.
3. *Astropecten luzonicus;* abactinal view of type, enlarged, p. 82.
4. *Astropecten pedicellaris;* abactinal view of type, enlarged, p. 87.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 14.

FIG. 1. *Astropecten phragmorus;* fourth inferomarginal plate and adjacent adambulacral plates of type, ×6.5. 1*a*. Same; fifth and sixth superomarginal plates of cotype, ×6.5; the part of the plates to left of dotted line forms part of the lateral wall of ray. 1*b*. Same; two paxillae from radial area, base of ray of cotype, ×9.6. P. 65.

2. *Astropecten velitaris;* fifth inferomarginal plate and adjacent adambulacral, ×9.6. P. 70.

3. *Astropecten cucnemis;* fourth inferomarginal plate and adjacent adambulacral of type, ×9.6. 3*a*. Same; mouth plates of type, ×9.6. 3*b*. Same; one of the larger paxillae, type, × 9.6. 3*c*. Same; fourth inferomarginal plate and adjacent adambulacral of small variety from station 5182, ×12. 3*d*. Same; an actinal interradial pedicellaria from specimen shown in 3*c*, ×12. P. 75.

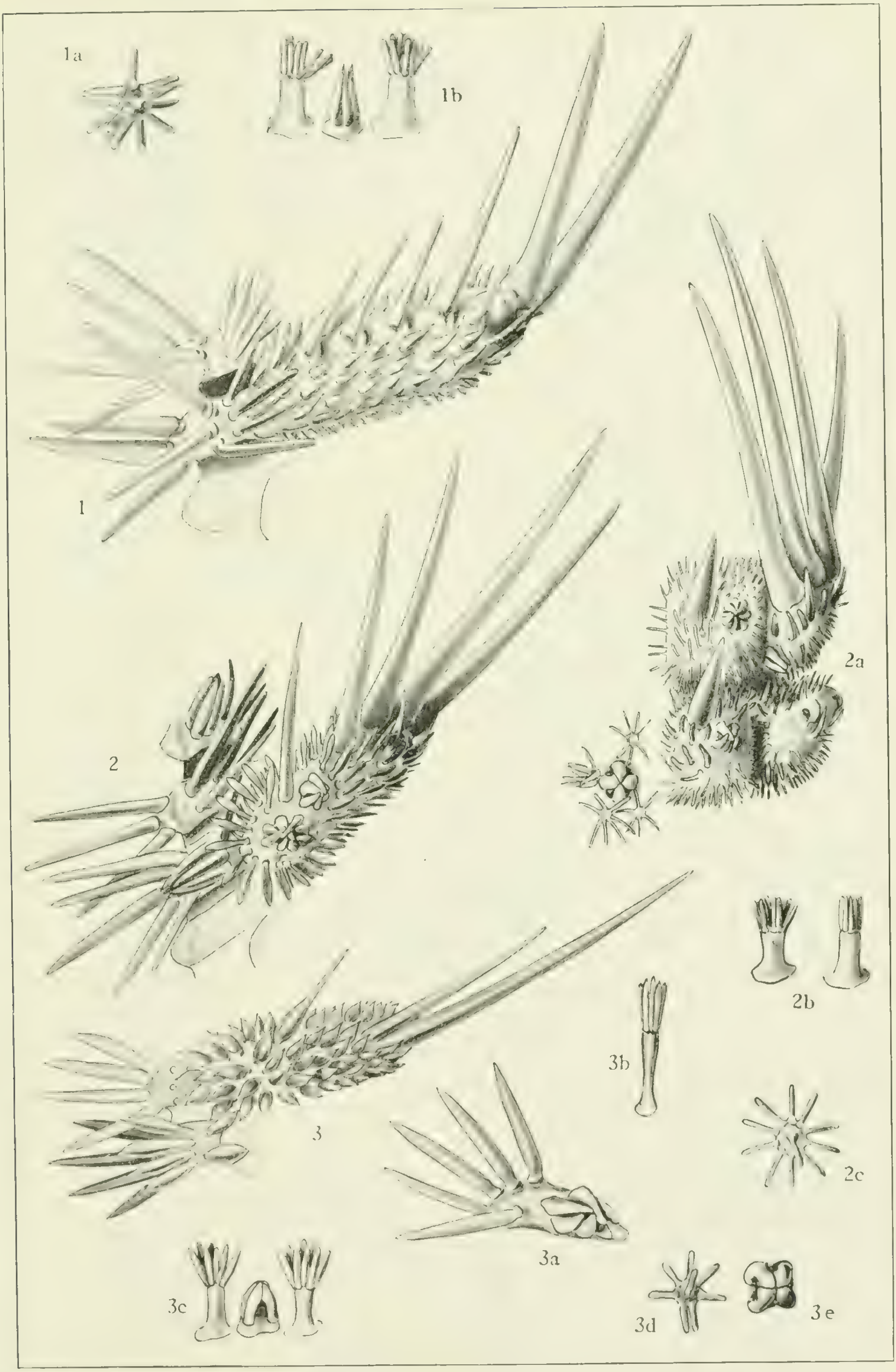
4. *Astropecten luzonicus;* sixth inferomarginal plate and 2 adjacent adambulacrals of type, ×9.6. 4*a*. Same; fifth superomarginal plate and upper end of corresponding inferomarginal, showing superomarginal spine, lateral spines, and also a few paxillae; ×9.6. 4*b*. Same; a paxilla from base of ray, ×9.6. P. 82.

PLATE 15.

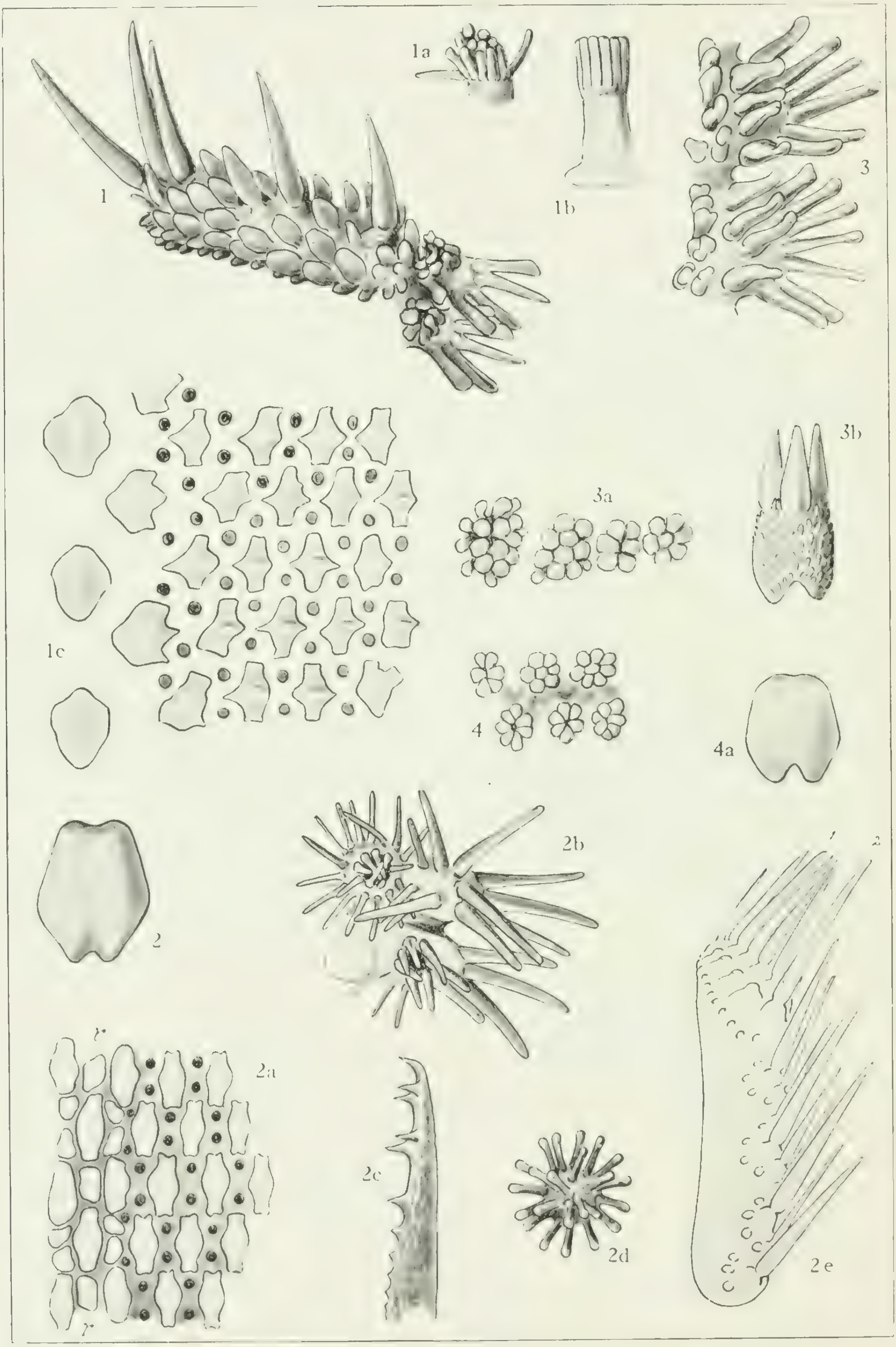
FIG. 1. *Astropecten tenellus;* fifth inferomarginal plate and adjacent adambulacrals of type, ×9.6. 1*a*. Same; paxilla from interradial region of disk, ×9.6. 1*b*. Same; a pedicellaria and 2 adjacent paxillae from radial area at base of ray, ×9.6. P. 84.

2. *Astropecten pedicellaris;* sixth inferomarginal plate and 4 adambulacral plates of type, ×9.6; note the adambulacral and inferomarginal pedicellariae. 2*a*. Same; ninth and tenth superomarginal plates, and upper end of corresponding inferomarginals, and also adjacent abactinal paxillae and pedicellaria, ×9.6; note superomarginal and inferomarginal pedicellariae; the inferomarginal spines have been removed from proximal plate; the superomarginal spines are longer at base of ray. 2*b*. Same; 2 paxillae from base of ray, side view, ×9.6. 2*c*. Same; a radial paxilla, expanded, ×9.6. P. 87.

3. *Astropecten eremicus;* ninth inferomarginal plate and 2 adjacent adambulacral plates of type, ×9.6. 3*a*. Same; third adambulacral plate of type, showing one of the large subambulacral pedicellariae, ×9.6. 3*b*. Same; side view of a paxilla from interradial line midway between center and margin, ×12 3*c*. Same; a pedicellaria and 2 adjacent paxillae from proximal third of ray, near radial line, ×12 3*d*. Same; paxilla from proximal third of ray near margin, ×12. 3*e*. Same; dorsal view of an abactinal pedicellaria, ×12. P. 79.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 16.

Fig. 1. *Ctenopleura astropectinides;* fourth inferomarginal and 2 adjacent adambulacral plates of type, ×4. 1*a*. Same; a paxilla from base of ray, ×8. 1*b*. Same; side view of paxilla, radial line of ray, ×8. 1*c*. Same; abactinal plates, from inner side; *r*—*r*, radial series of plates of ray, ×8. P. 91.

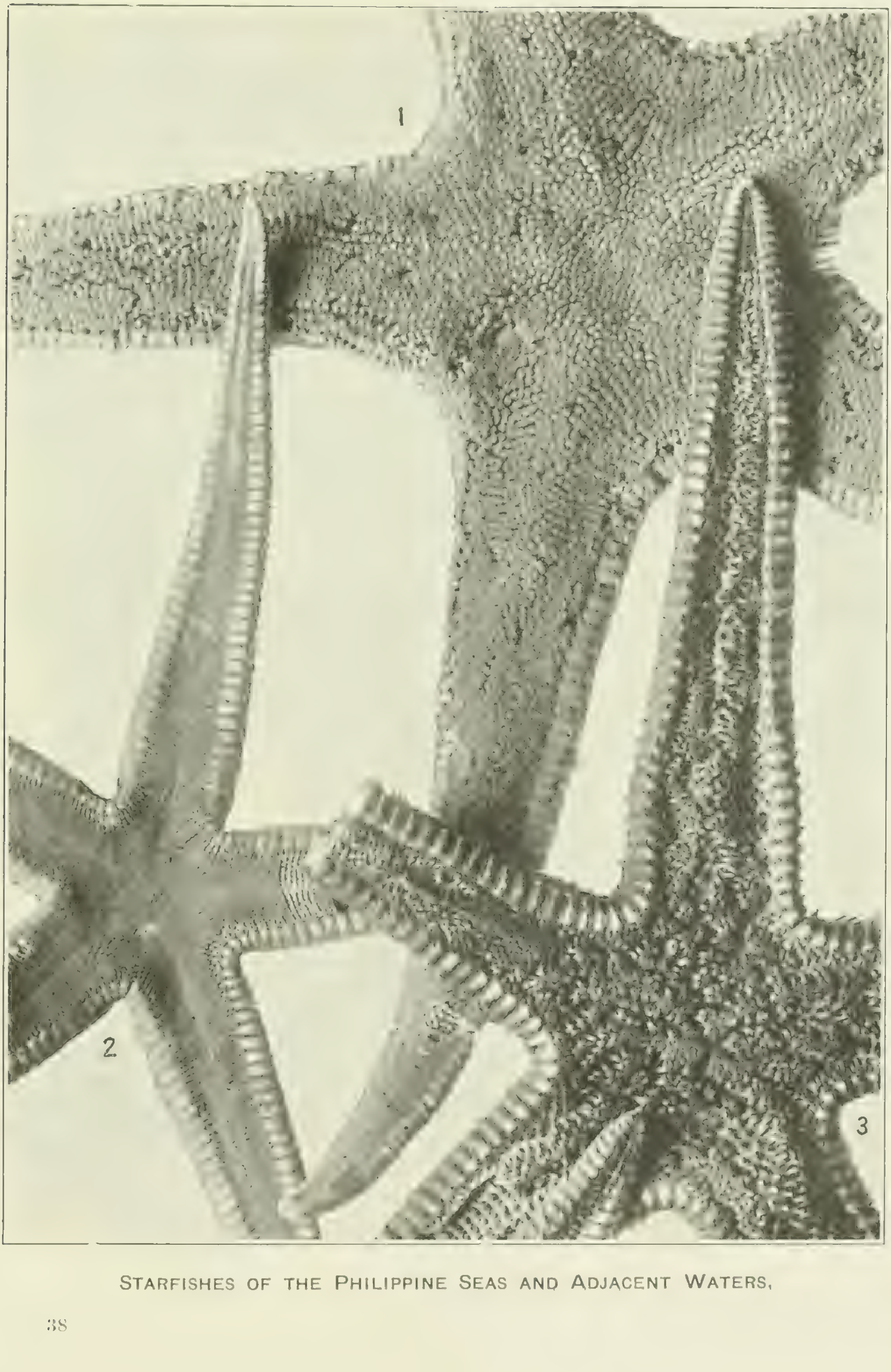
2. *Ctenophoraster diploctenius;* terminal plate, denuded, ×8. 2*a*. Same; abactinal plates, from inner side; *r*—*r*, radial series of plates, base of ray, ×8. 2*b*. Same; ninth and tenth adambulacral plates and adjacent actinal intermediate plates, ×8. 2*c*. Same; tip of a lateral inferomarginal spine, much enlarged. 2*d*. Same; abactinal paxilla, ×16. 2*e*. Same; eighth inferomarginal plate showing the second comb of lateral spines (1) and a single spine (2) of the outer lateral series; the actinal spines are shown, and the circular scars of the accessory spinules, ×6.5. P. 95.

3. *Psilaster gotoi;* eighth and ninth adambulacral plates of type. 3*a*. Same; abactinal paxillae from base of ray, that to left being one of a radial series, ×16. 3*b*. Same; terminal plate, ×8. P. 100.

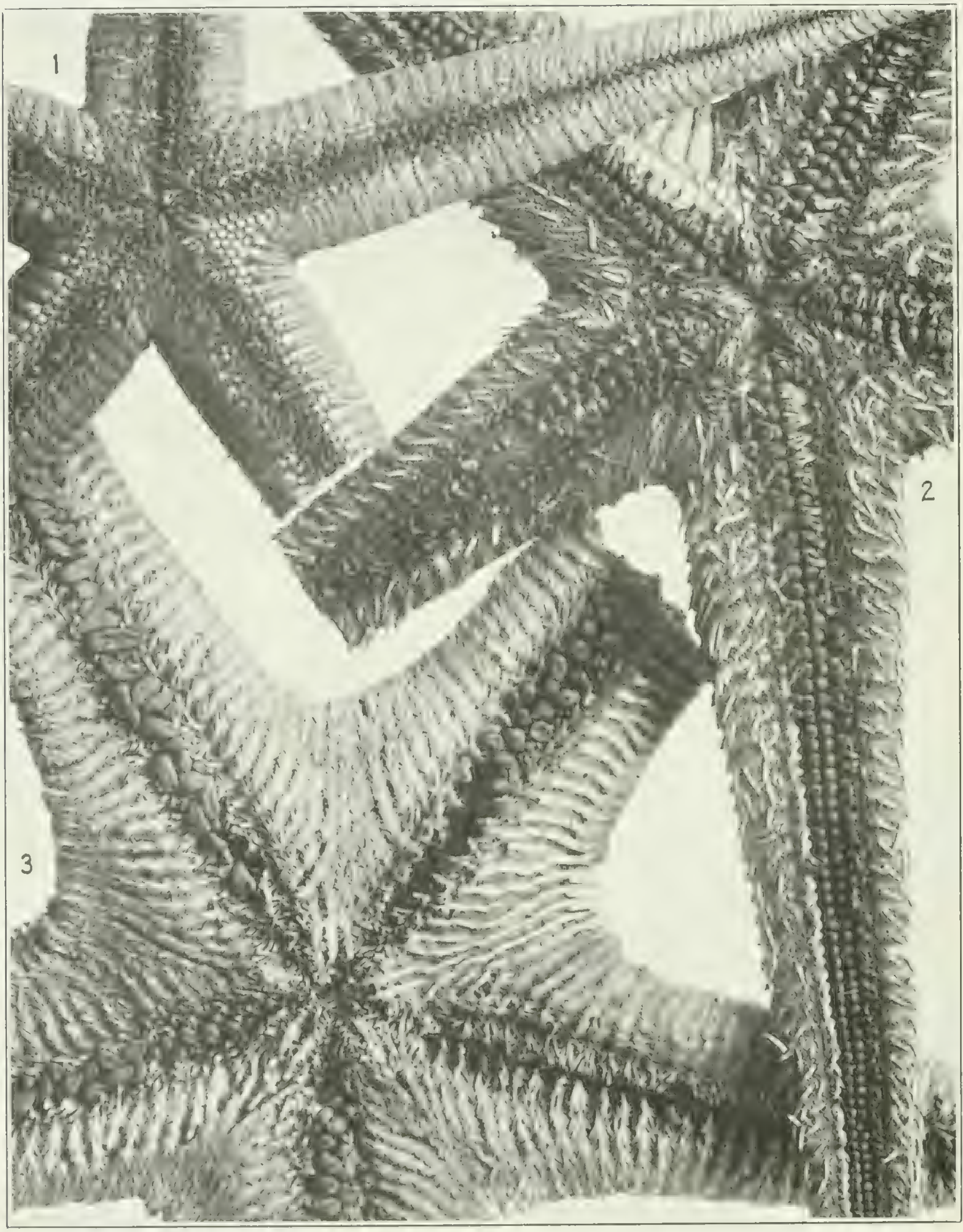
4. *Psilaster robustus;* abactinal paxillae, ×16. 4*a*. Same; terminal plate, denuded. P. 103.

PLATE 17.

FIG. 1. *Anthosticte aulophora;* type, abactinal view, reduced, p. 140.
2. *Ctenophoraster diploctenius;* type, abactinal view, p. 95.
3. *Ctenopleura astropectinides;* type, abactinal view, p. 91.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



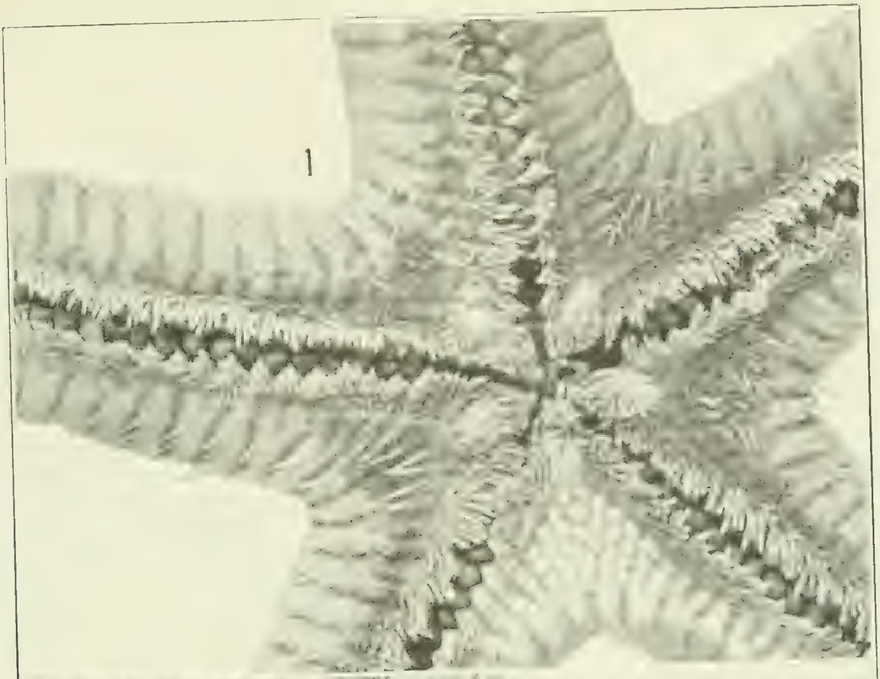
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 18.

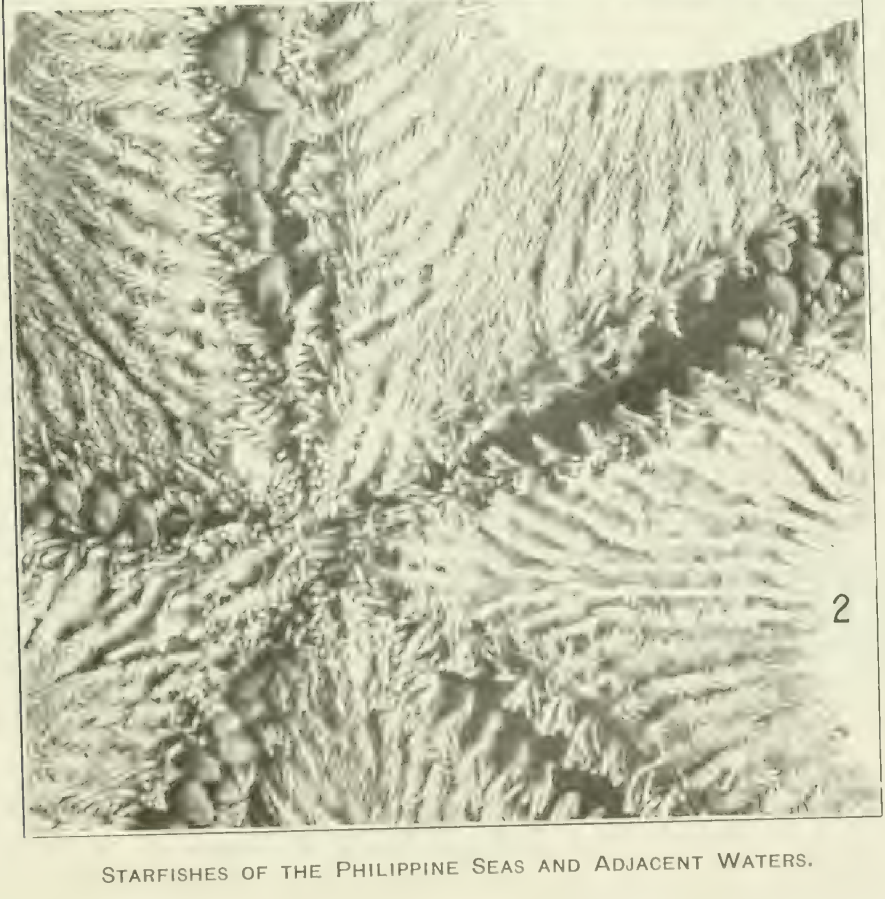
FIG. 1. *Ctenophoraster diploctenius;* type, actinal surface, p. 95.
2. *Ctenopleura astropectinides;* type, actinal surface, p. 91.
3. *Anthosticte aulophora;* type, actinal surface, p. 140.

Plate 19.

Fig. 1. *Astromesites compactus;* portion of actinal surface, enlarged, p. 107.
2. *Anthosticte aulophora;* portion of actinal surface, enlarged, p. 140.

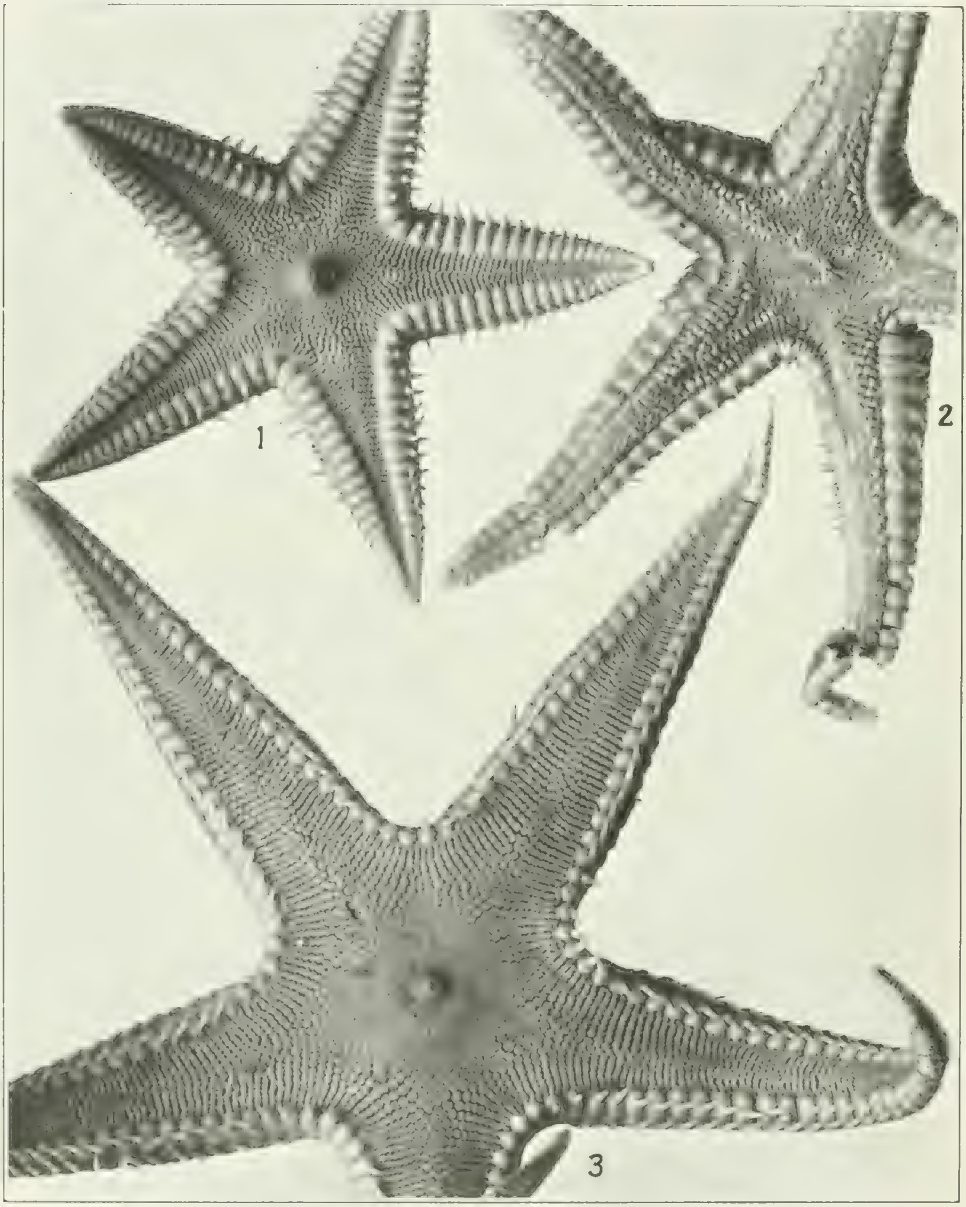


1



2

Starfishes of the Philippine Seas and Adjacent Waters.



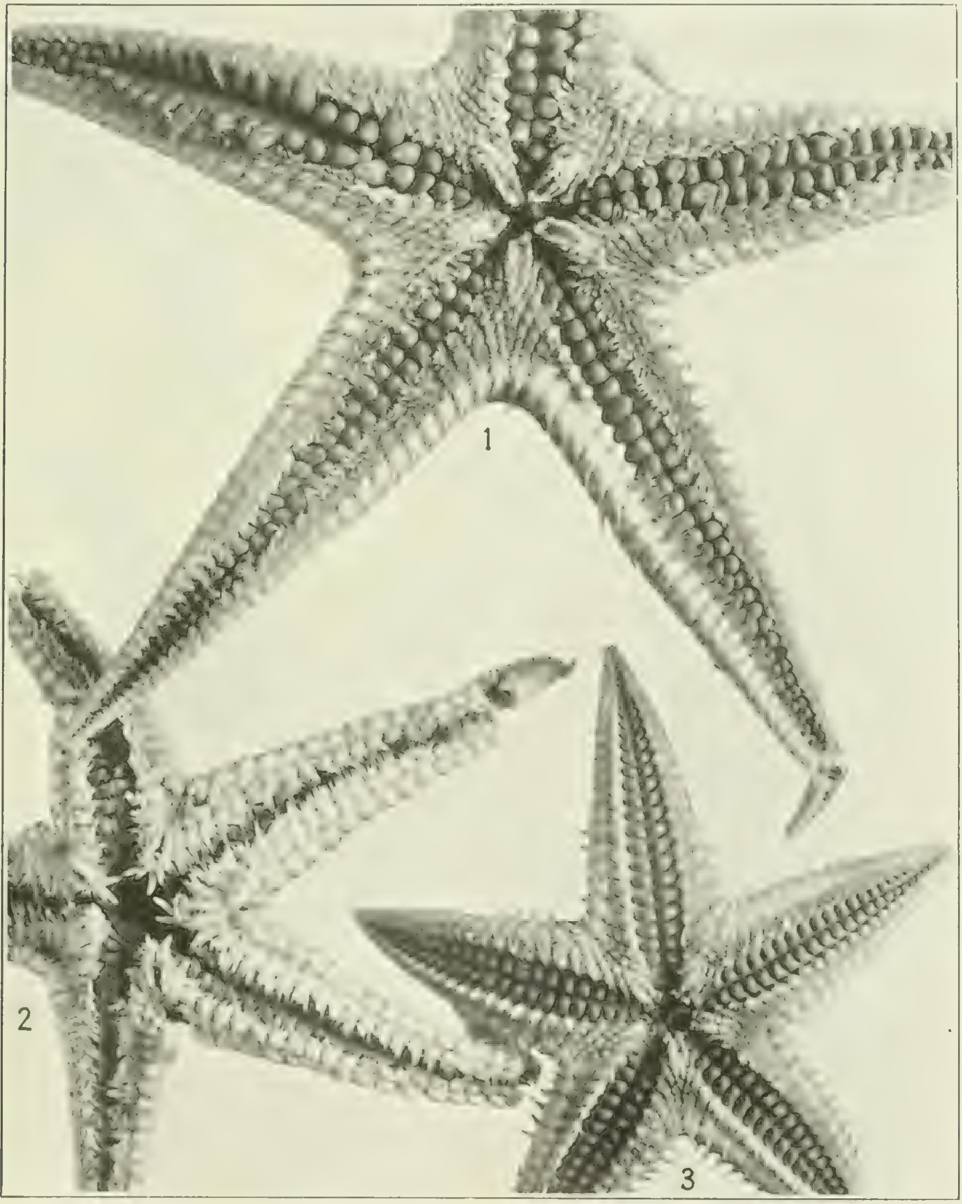
Starfishes of the Philippine Seas and Adjacent Waters.

Plate 20.

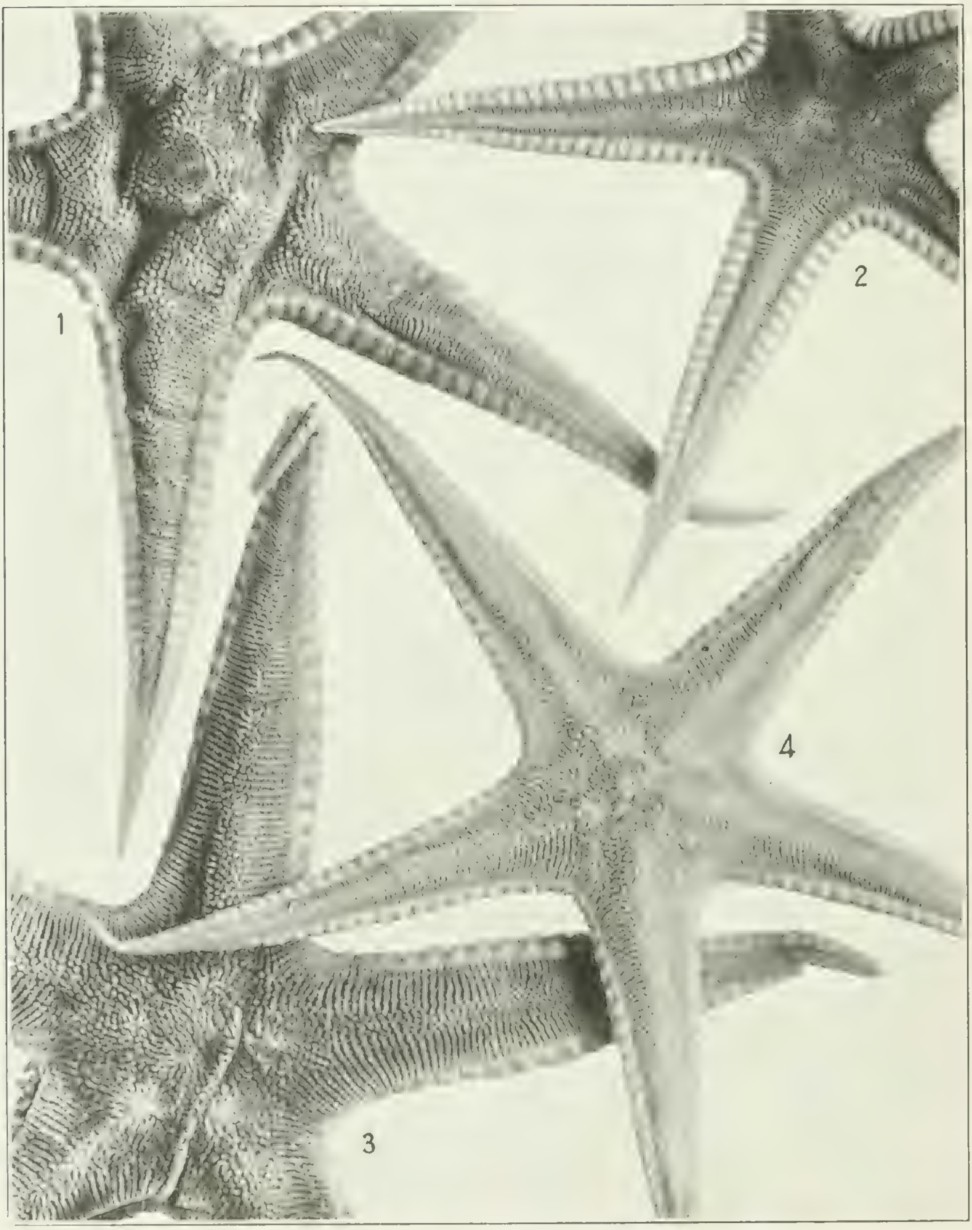
Fig. 1. *Psilaster robustus;* type, abactinal aspect, p. 103.
2. *Persephonaster monostoechus;* type, abactinal surface, p. 134.
3. *Psilaster gotoi;* type, abactinal surface, p. 100.

PLATE 21.

FIG. 1. *Psilaster gotoi;* type, actinal surface, p. 100.
2. *Persephonaster monostoechus;* type, actinal surface, p. 134.
3. *Psilaster robustus;* type, actinal surface, p. 103.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



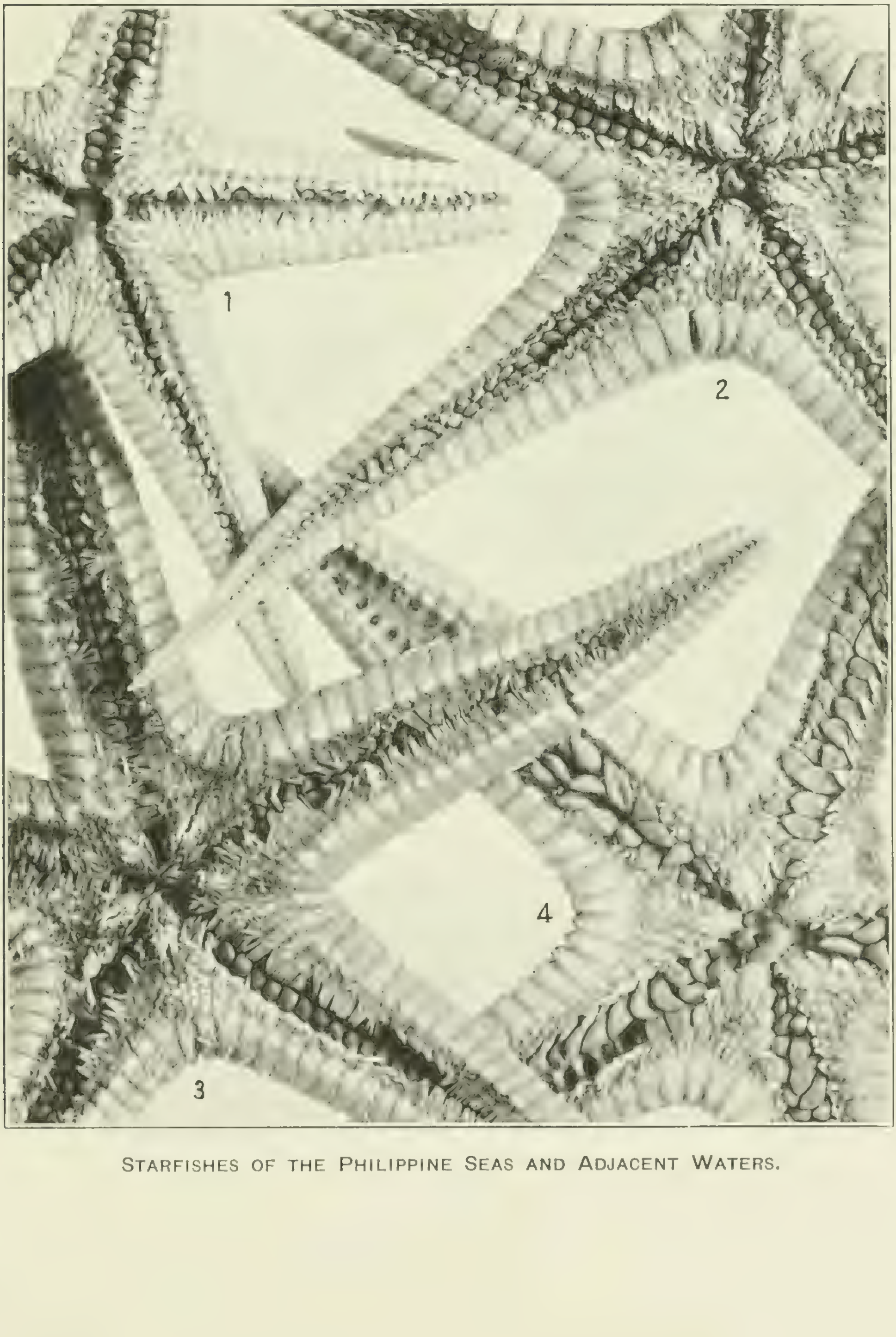
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 22.

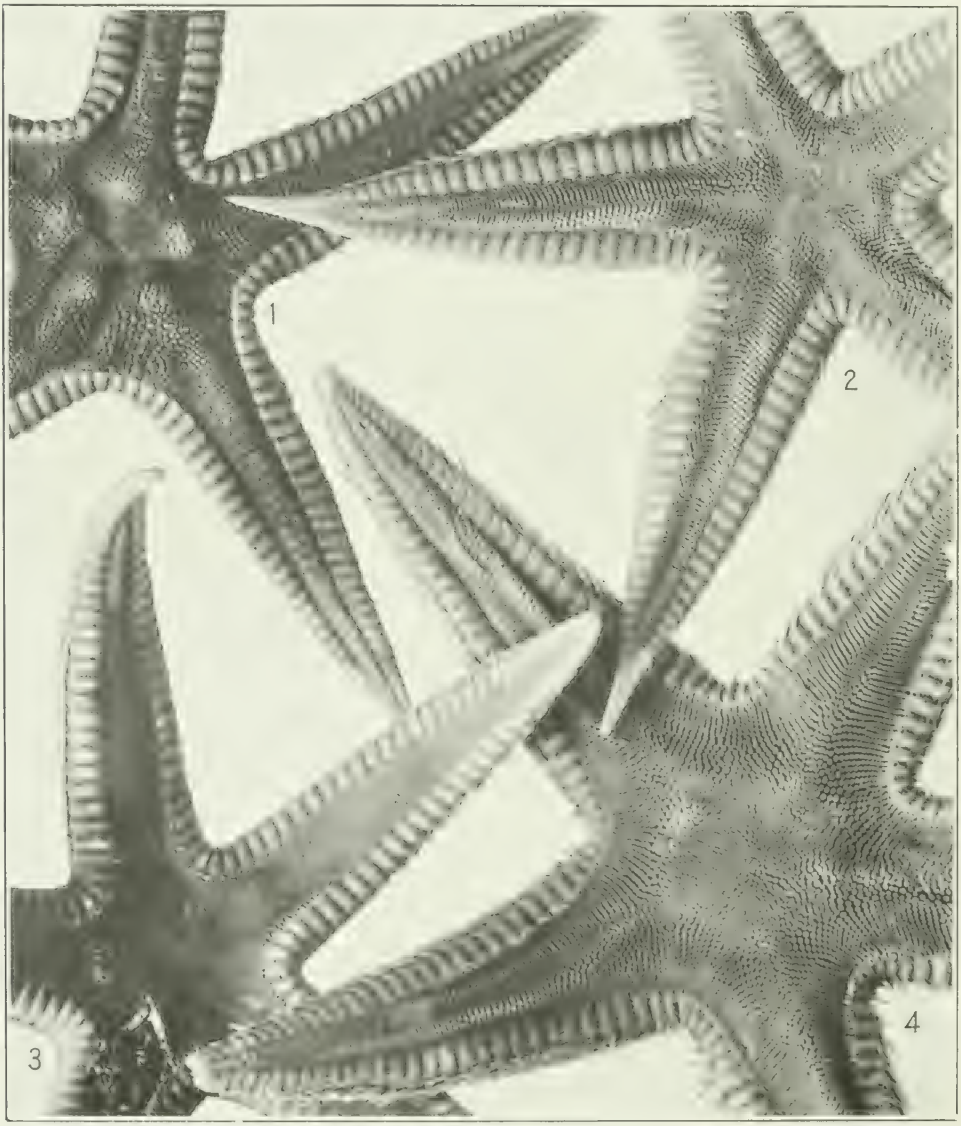
FIG. 1. *Persephonaster tenuis;* type, abactinal view, p. 121.
2. *Persephonaster suluensis;* type, abactinal view, p. 125.
3. *Persephonaster oediplax;* type, abactinal view, p. 127.
4. Same; a smaller specimen.

PLATE 23.

Fig. 1. *Persephonaster suluensis;* type, actinal view, p. 125.
2. *Persephonaster tenuis;* type, actinal view, p. 121.
3. *Persephonaster luzonicus;* type, actinal view, p. 118.
4. *Persephonaster oediplax;* type, actinal view, p. 127.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



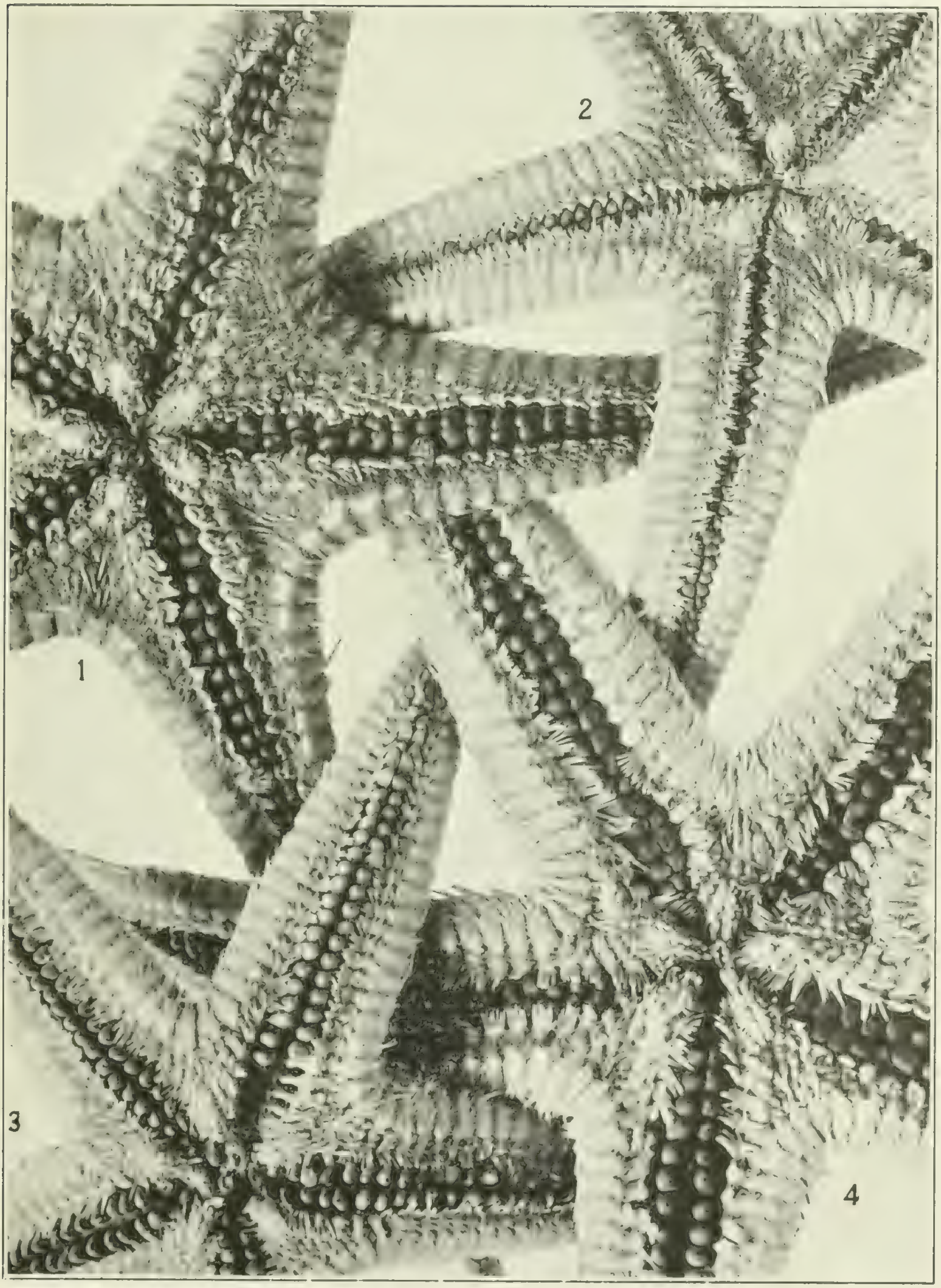
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 24.

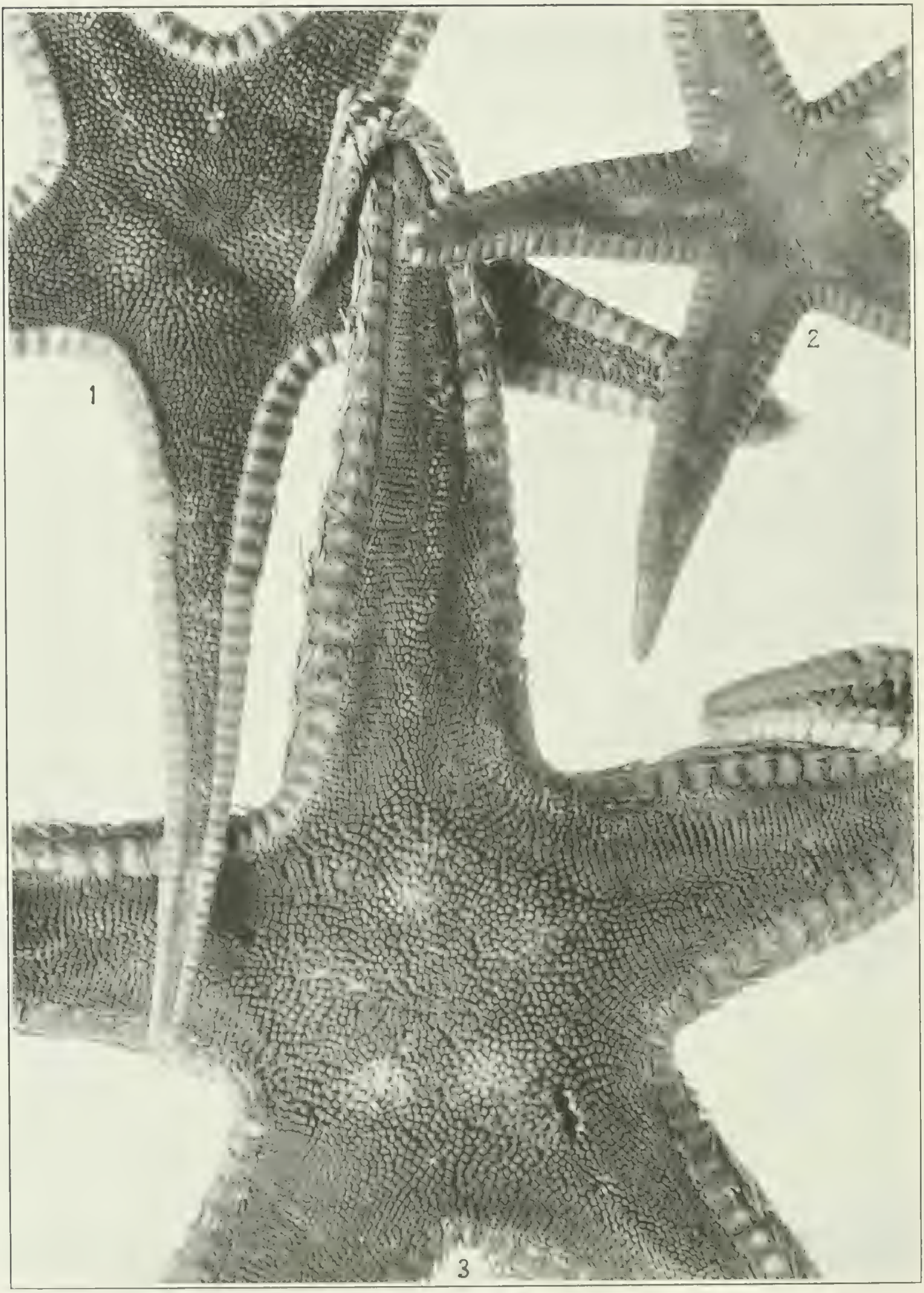
Fig. 1. *Persephonaster luzonicus;* type, abactinal surface, p. 118.
2. *Persephonaster euryactis brevispinus;* abactinal surface, p. 115.
3. *Astromesites compactus;* type, abactinal surface, p. 107.
4. *Persephonaster euryactis;* type, abactinal surface, p. 112.

PLATE 25.

FIG. 1. *Persephonaster multicinctus;* type, actinal view, p. 123.
2. *Astromesites compactus;* type, actinal view, p. 107.
3. *Persephonaster euryactis brevispinus;* actinal view, p. 115.
4. *Persephonaster euryactis;* type, actinal view, p. 112.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 26.

FIG. 1. *Persephonaster multicinctus;* type, abactinal view, p. 123.

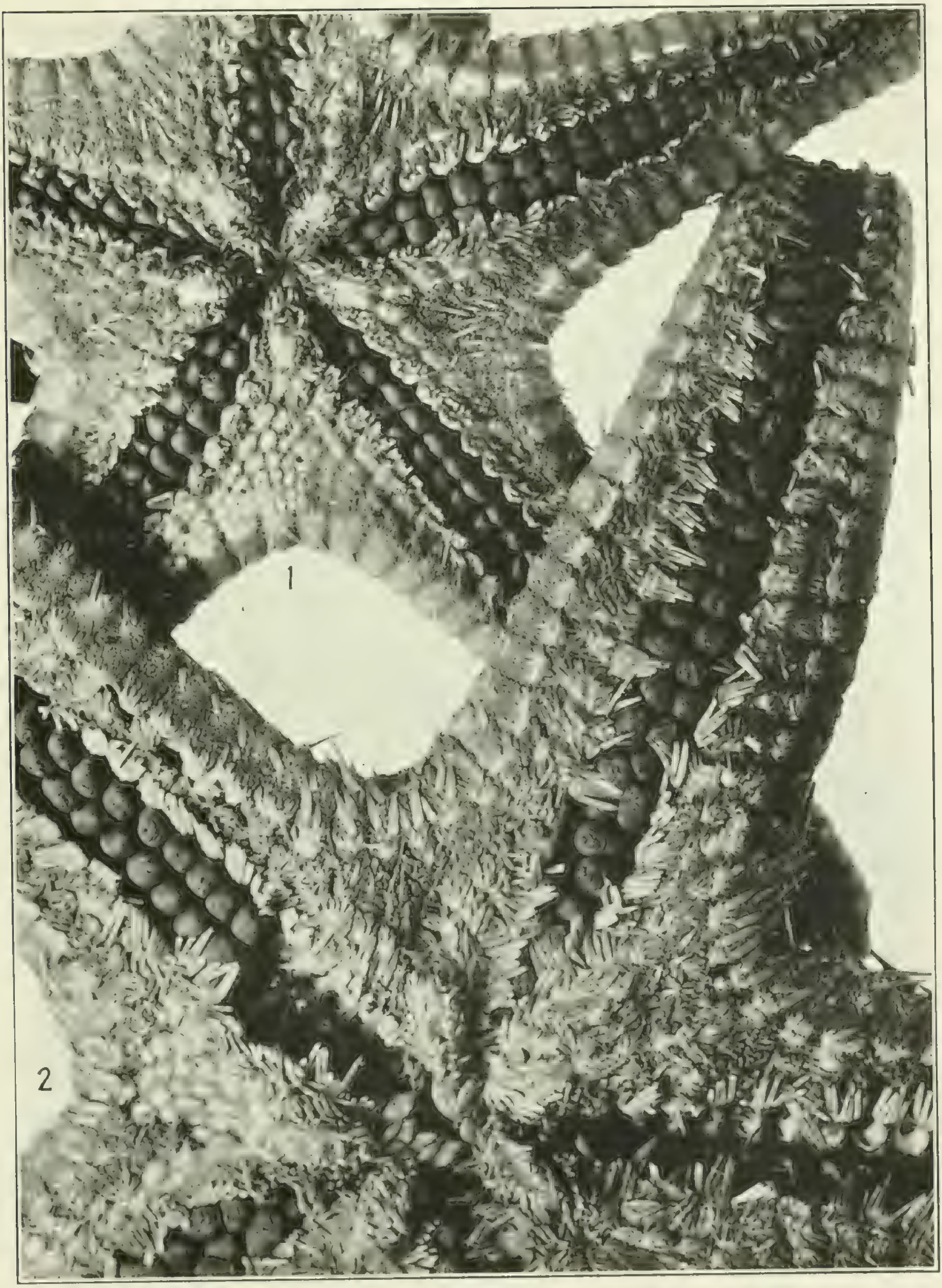
2. *Astromesites compactus;* specimen from station 5296, p. 107.

3. *Persephonaster anchistus;* abactinal view of type, p. 117.

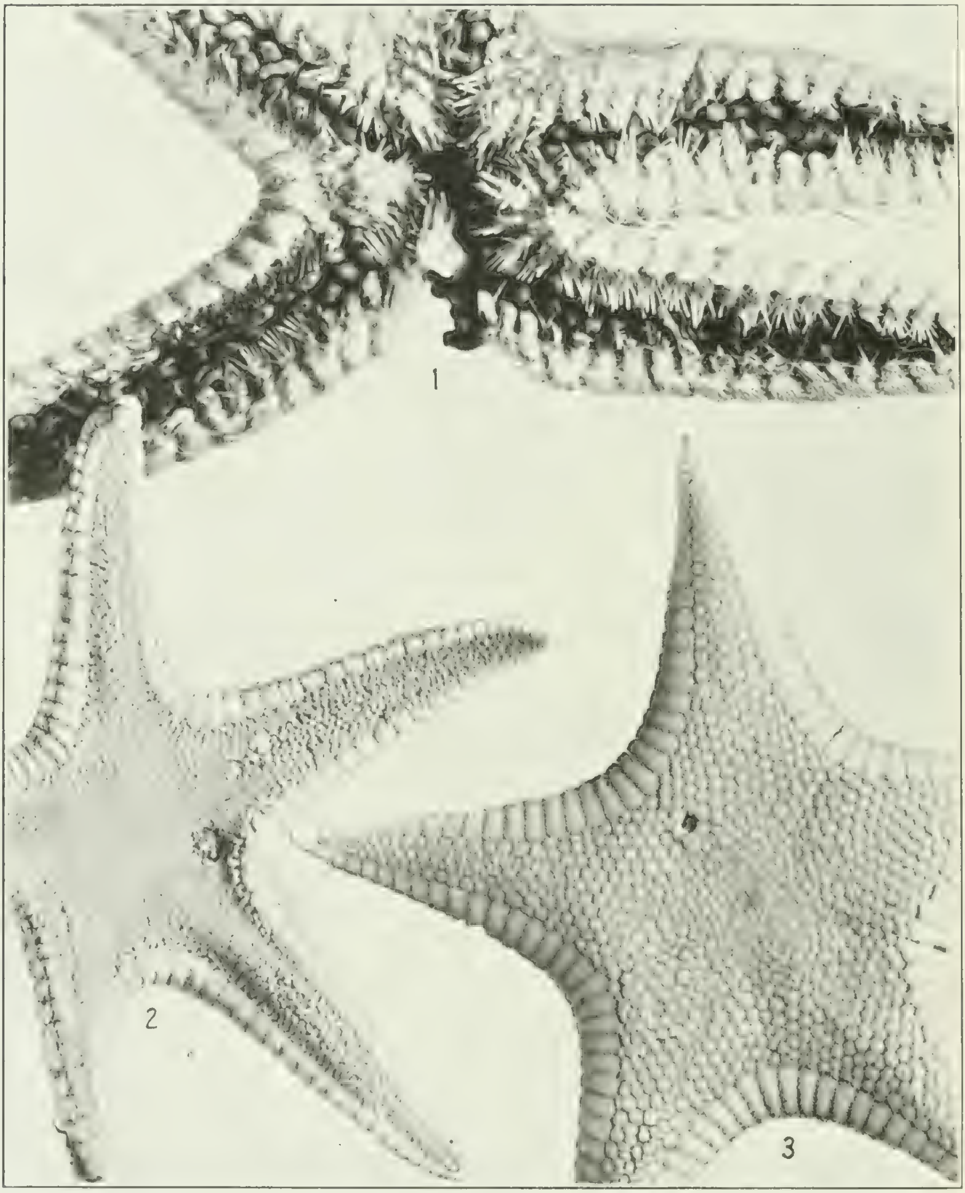
PLATE 27.

FIG. 1. *Persephonaster multicinctus;* actinal view of type, much enlarged, p. 123

2. *Persephonaster anchistus;* actinal view of type, much enlarged, p. 117.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



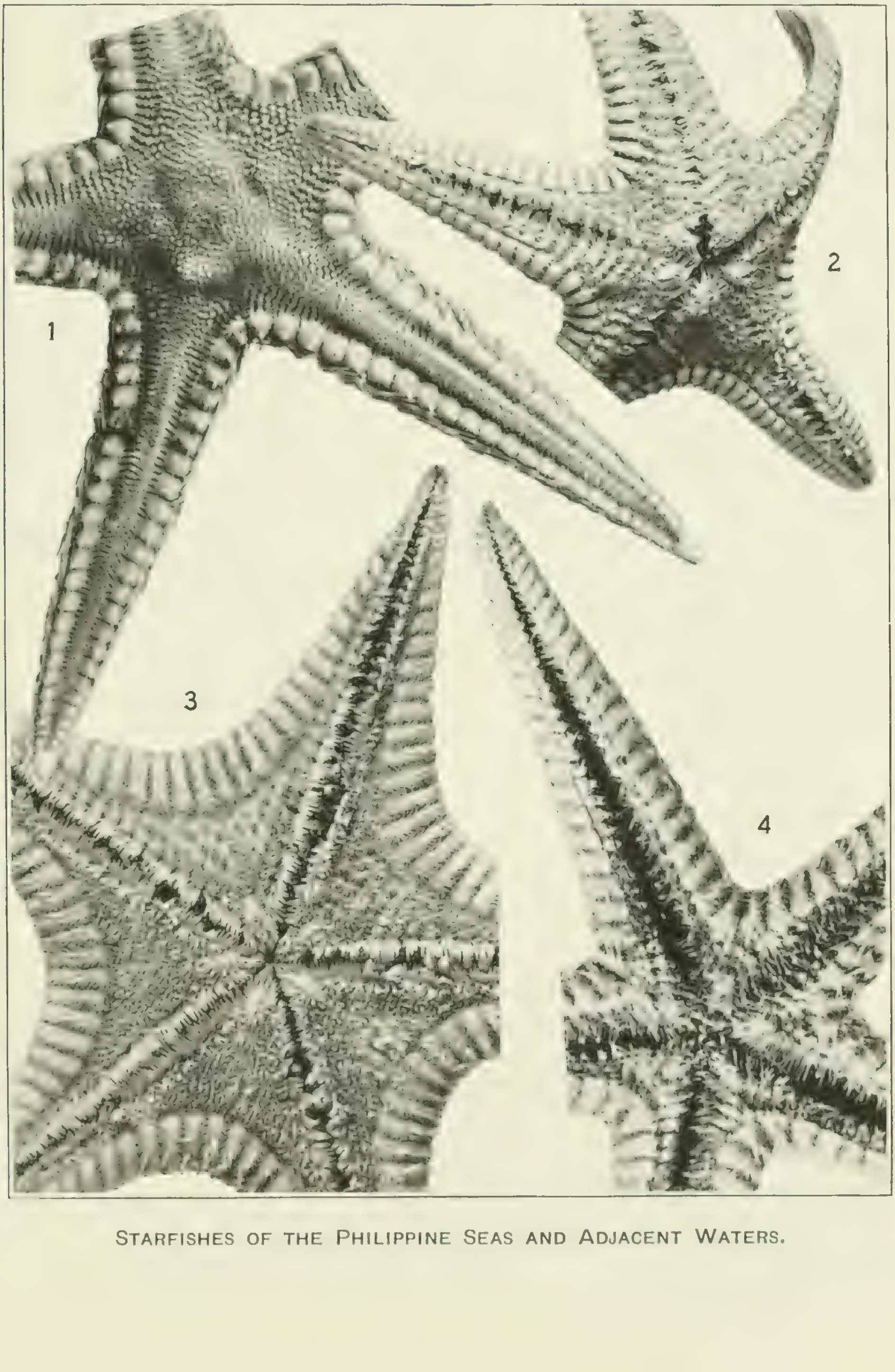
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 28.

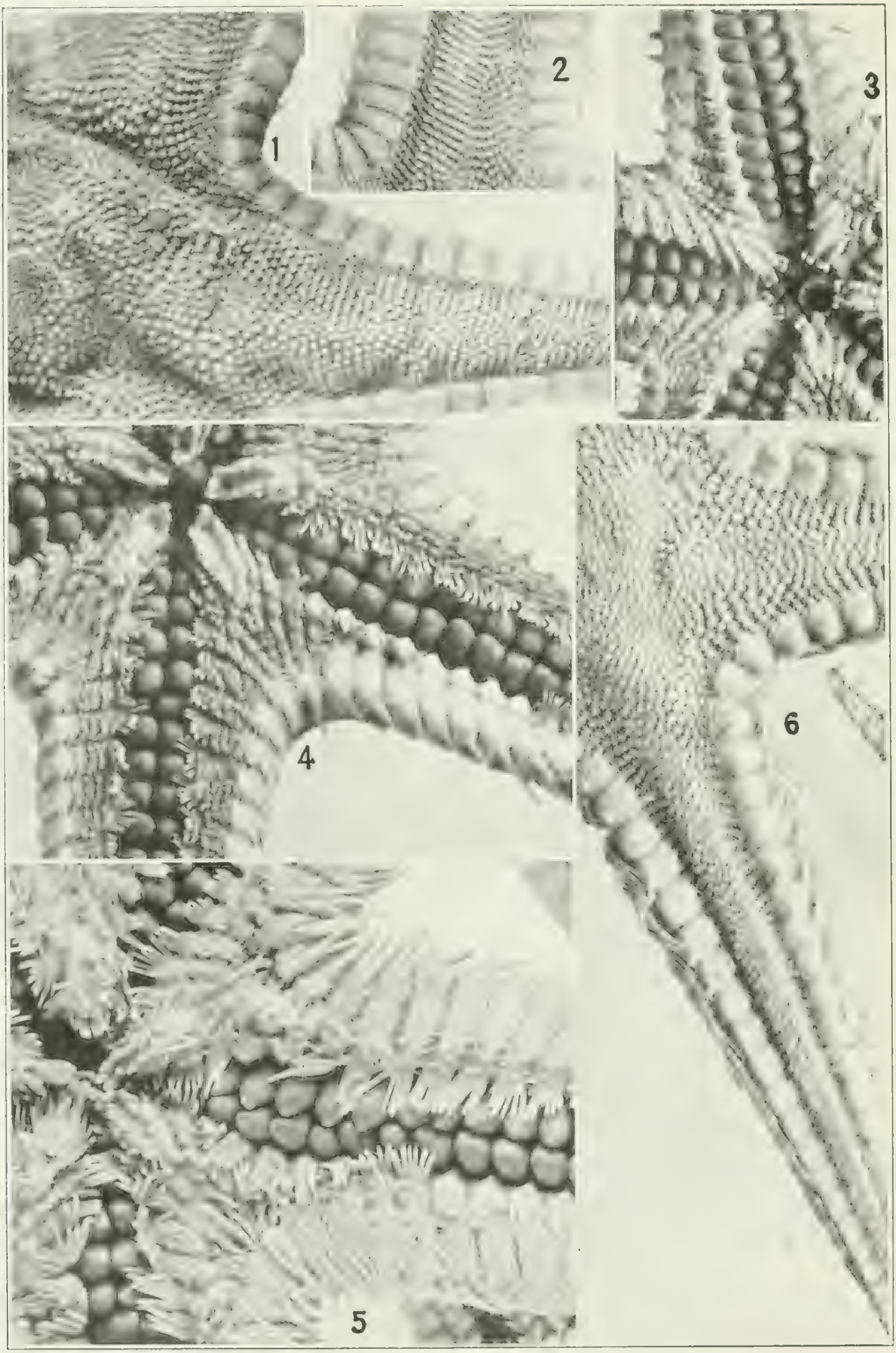
FIG. 1. *Persephonaster habrogenys;* actinal view of type, enlarged, p. 131.
2. *Dipsacaster diaphorus;* abactinal view of type, enlarged, p. 152.
3. *Patagiaster sphaerioplax;* abactinal view of type, enlarged, p. 154.

PLATE 29.

FIG. 1. *Tritonaster evorus;* abactinal view of type, enlarged, p. 136.
2. *Dipsacaster diaphorus;* actinal view of type, enlarged, p. 152.
3. *Patagiaster sphaeriophax;* actinal view of type, enlarged, p. 154.
4. *Tritonaster evorus;* actinal view of type, enlarged, p. 136.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 30.

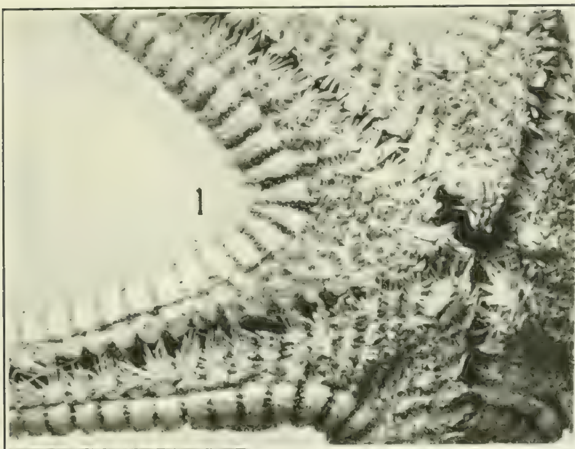
Enlarged details of abactinal and actinal surfaces.

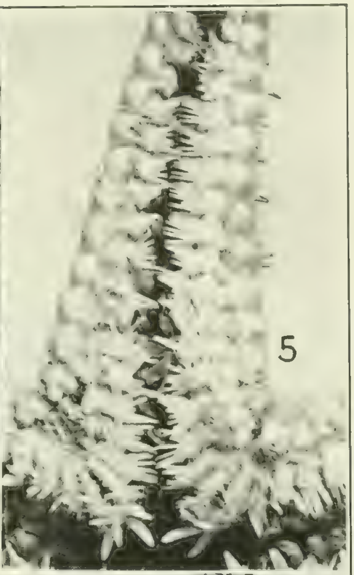
Fig. 1. *Persephonaster tenuis;* abactinal, p. 121.
2. *Persephonaster euryactis brevispinus;* abactinal, p. 115.
3. *Psilaster robustus;* actinal, p. 103.
4. *Psilaster gotoi;* actinal, p. 100.
5. *Persephonaster euryactis;* actinal, p. 112.
6. *Tritonaster evorus;* abactinal, p. 136.

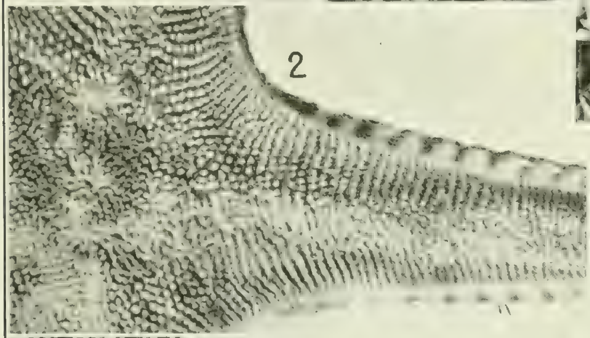
PLATE 31.

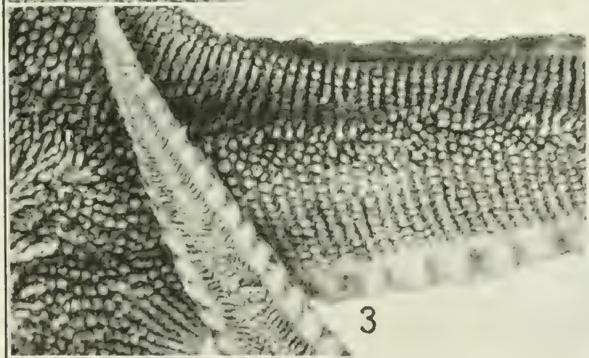
Enlarged details of abactinal and actinal surfaces.

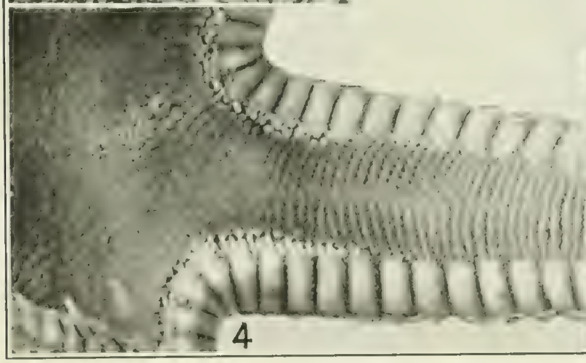
FIG. 1. *Dipsacaster diaphorus;* actinal, p. 152.
2, 3. *Persephonaster oediplax;* abactinal, p. 127.
4. *Astromesites compactus;* abactinal, p. 107.
5. *Persephonaster monostoechus;* actinal, p. 134.
6. *Persephonaster habrogenys;* abactinal, p. 131.

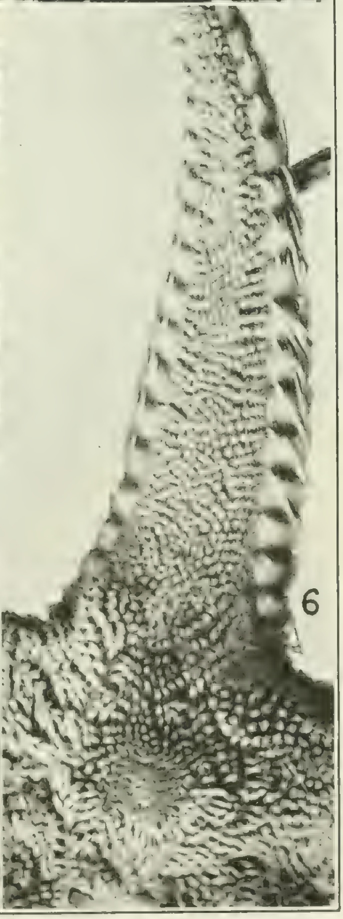




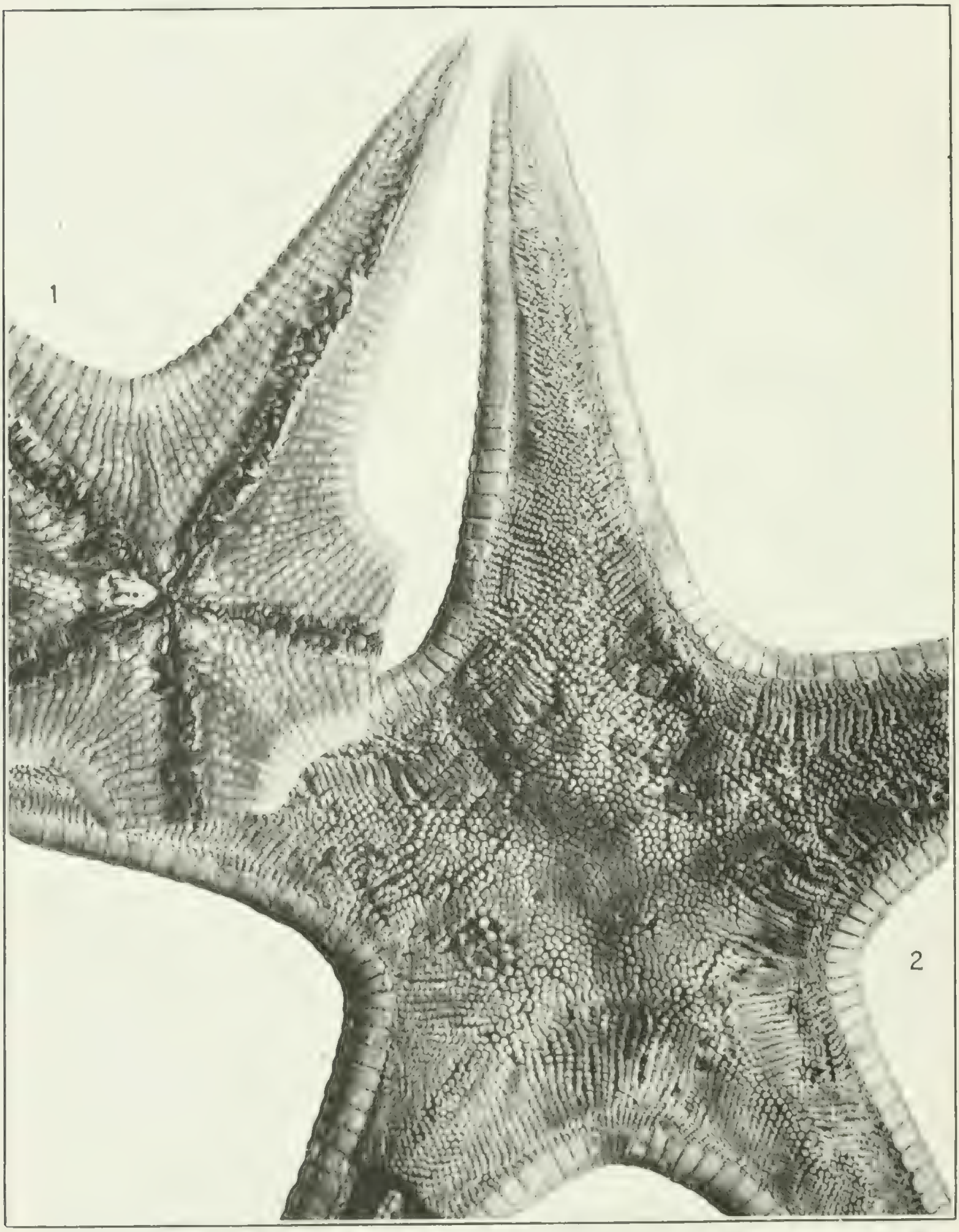








STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 32.

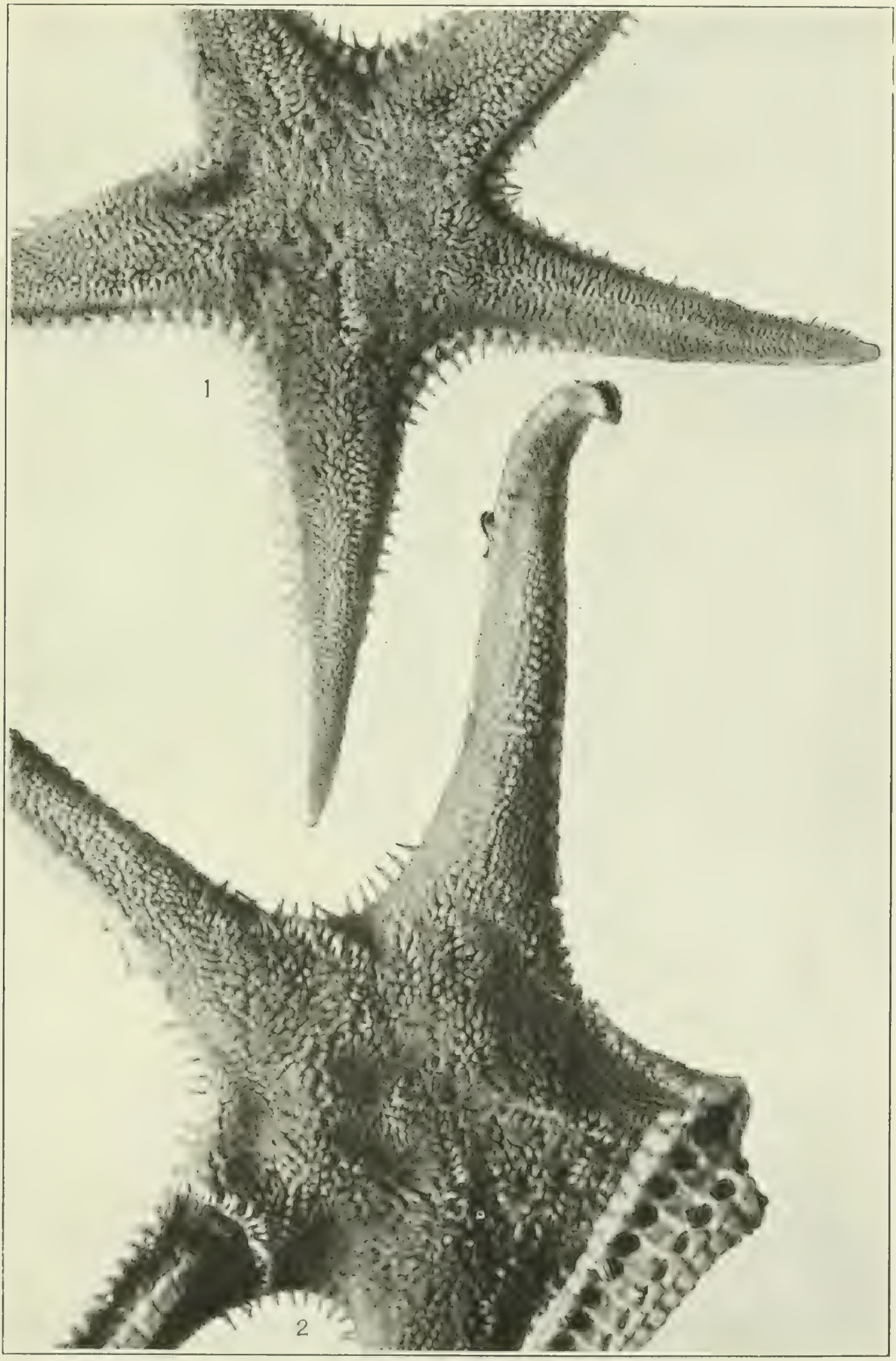
Dipsacaster imperialis.

FIG. 1. Actinal surface of type, reduced; one pair of mouth plates has been cleaned, p. 146.

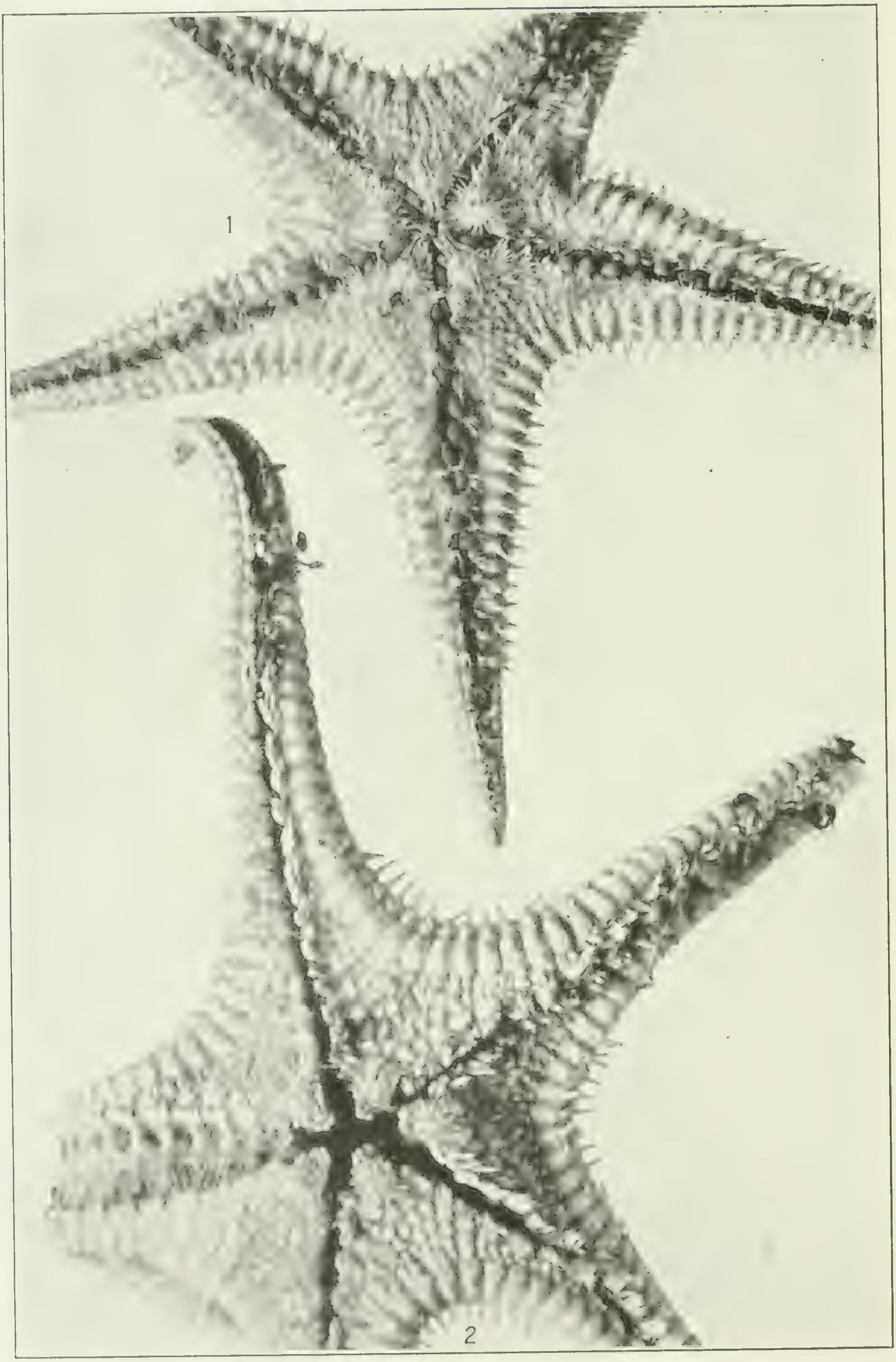
2. Abactinal surface of type, reduced.

PLATE 33.

FIG. 1. *Korcmaster cvaulus spiculatus;* abactinal view of type, enlarged, p. 161.
2. *Korcmaster evaulus;* abactinal view of type, enlarged, p. 157.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 34.

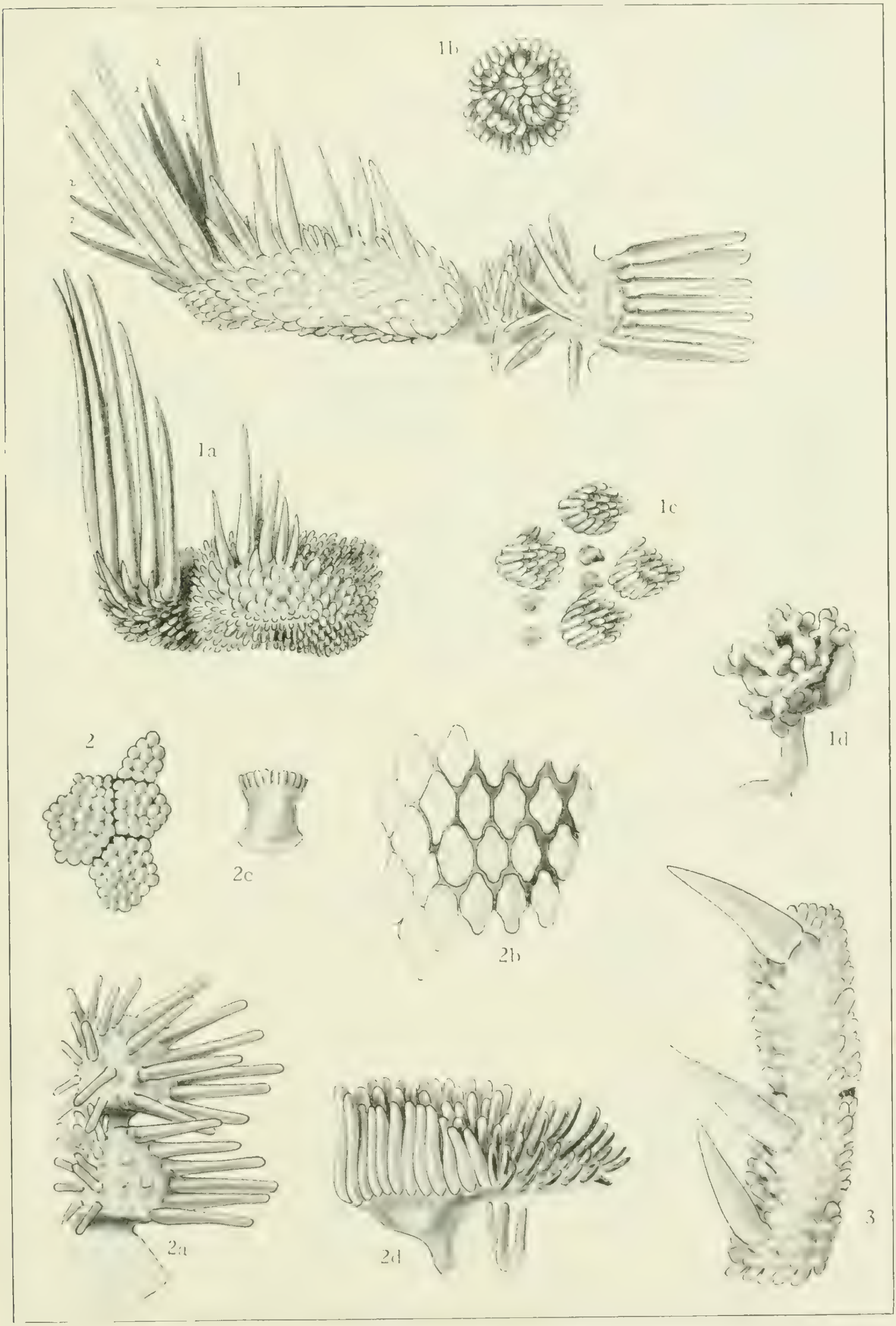
FIG. 1. *Koremaster evaulus spiculatus;* actinal view of type, enlarged, p. 161.
2. *Koremaster evaulus;* actinal view of type, enlarged, p. 157.

PLATE 35.

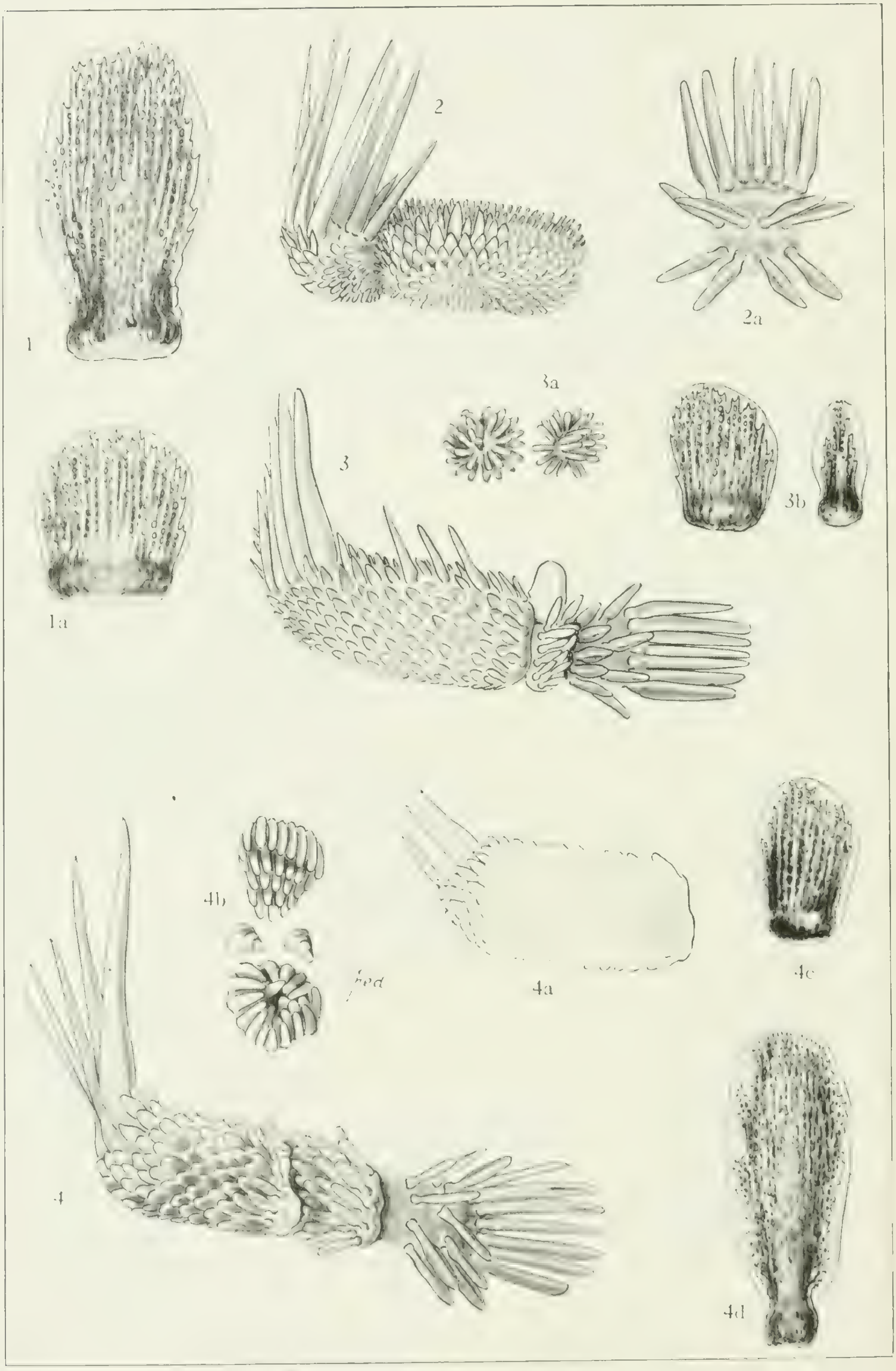
FIG. 1. *Persephonaster euryactis;* inferomarginal, actinal intermediate, and adambulacral plates from proximal portion of ray of type, × 6.5. The figures 2, 2, 2, indicate the second underlying comb of inferomarginal spines. 1*a*. Same; twelfth inferomarginal and superomarginal plates of type; note the increased length of the inferomarginal spines, × 6.5. 1*b*. Same; a primary basal paxilla, × 16. 1*c*. Same; paxillae from the base of ray just to one side of the radial line, × 16. 1*d*. Same; Polian vesicle, × 4. P. 112.

2. *Astromesites compactus*, type; large paxillae from near madreporic body, × 8. 2*a*. Same; twelfth to fourteenth adambulacral plates, × 8. 2*b*. Same; abactinal plates from base of ray, × 8. 2*c*. Same; a side view of a paxilla from radial region of ray, × 8. 2*d*. Same; side view of mouth plates, × 6.5. P. 107.

3. *Psilaster gotoi*, type; sixth superomarginal and inferomarginal plates, p. 100.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 36.

Fig. 1. *Persephonaster euryactis;* spinelet from near inner edge of inferomarginal plate, × 52. 1*a*. Same; spinelet from outer part of inferomarginal plate, × 52. P. 112.

2. *Persephonaster euryactis brevispinus;* twelfth superomarginal plate, and upper end of adjacent inferomarginal plate, showing the small superomarginal spines; second row of lateral spines marked 2; × 6.5. 2*a*. Same; eighth adambulacral plate, × 6.5. P. 115.

3. *Persephonaster luzonicus*, type; sixth inferomarginal and adjacent actinal intermediate and adambulacral plates, × 6.5. 3*a*. Same; paxillae from base of ray; a pedicellaria is shown on the left; × 16. 3*b*. Same; spinelets from interomarginal plates, × 52. P. 118.

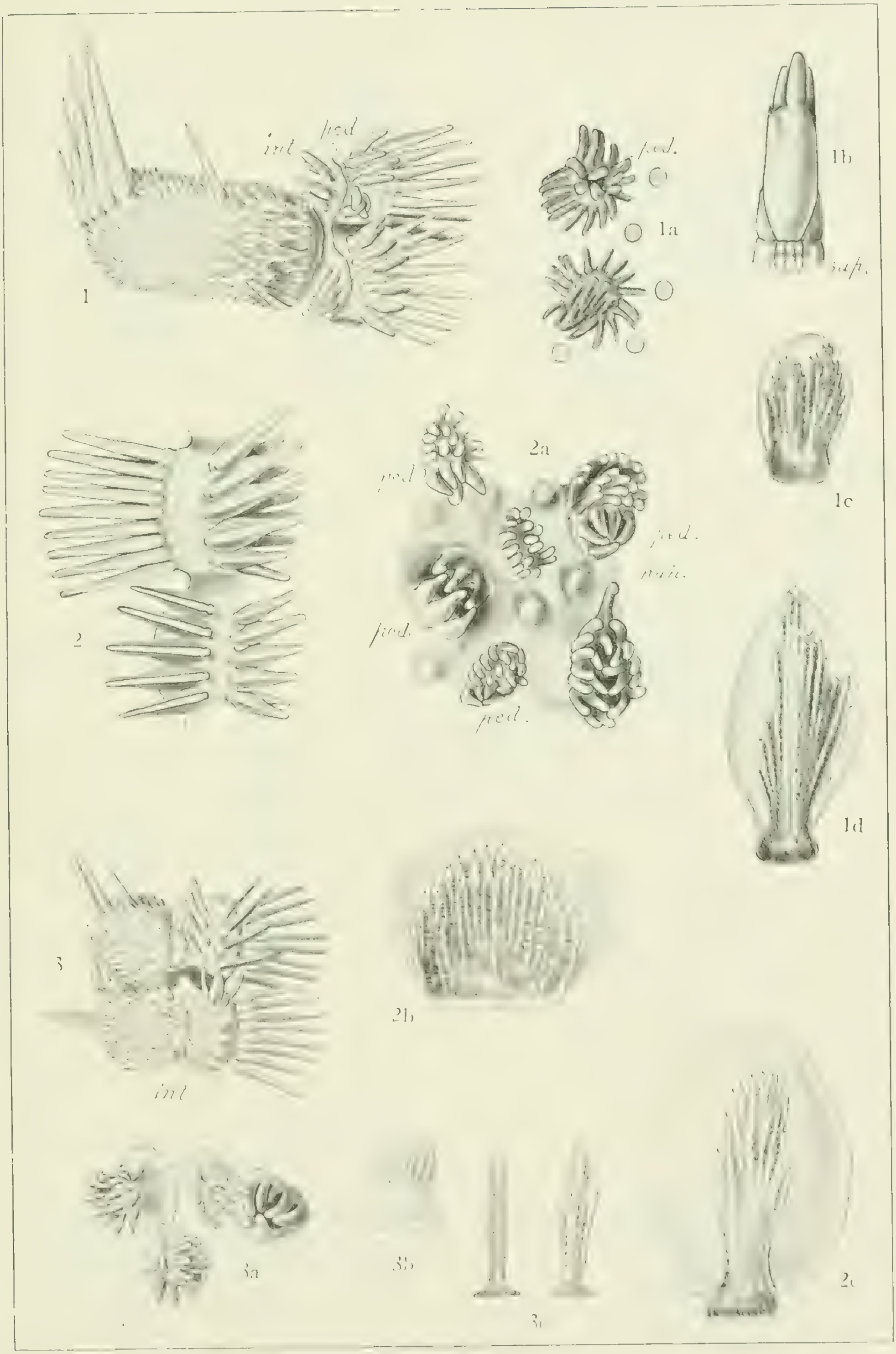
4. *Persephonaster anchistus*, type; fifth inferomarginal and adjacent actinal intermediate and adambulacral plates. × 4. The inferomarginal appears to be narrower than it really is on account of foreshortening. The series form a beveled border to ray. 4*a*. Same; outline of an inferomarginal plate, viewed without foreshortening, × 4. 4*b*. Same; 2 paxillae from radial line, base of ray, showing a pedicellaria (*ped.*) and 2 papulae, × 16. 4*c*. A spinelet from near middle of inferomarginal plate, × about 28; note that the magnification is about half that of *P. euryactis* and *P. luzonicus*. 4*d*. Same; spinelet from near inner edge of inferomarginal plate, × 28. P. 117.

PLATE 37.

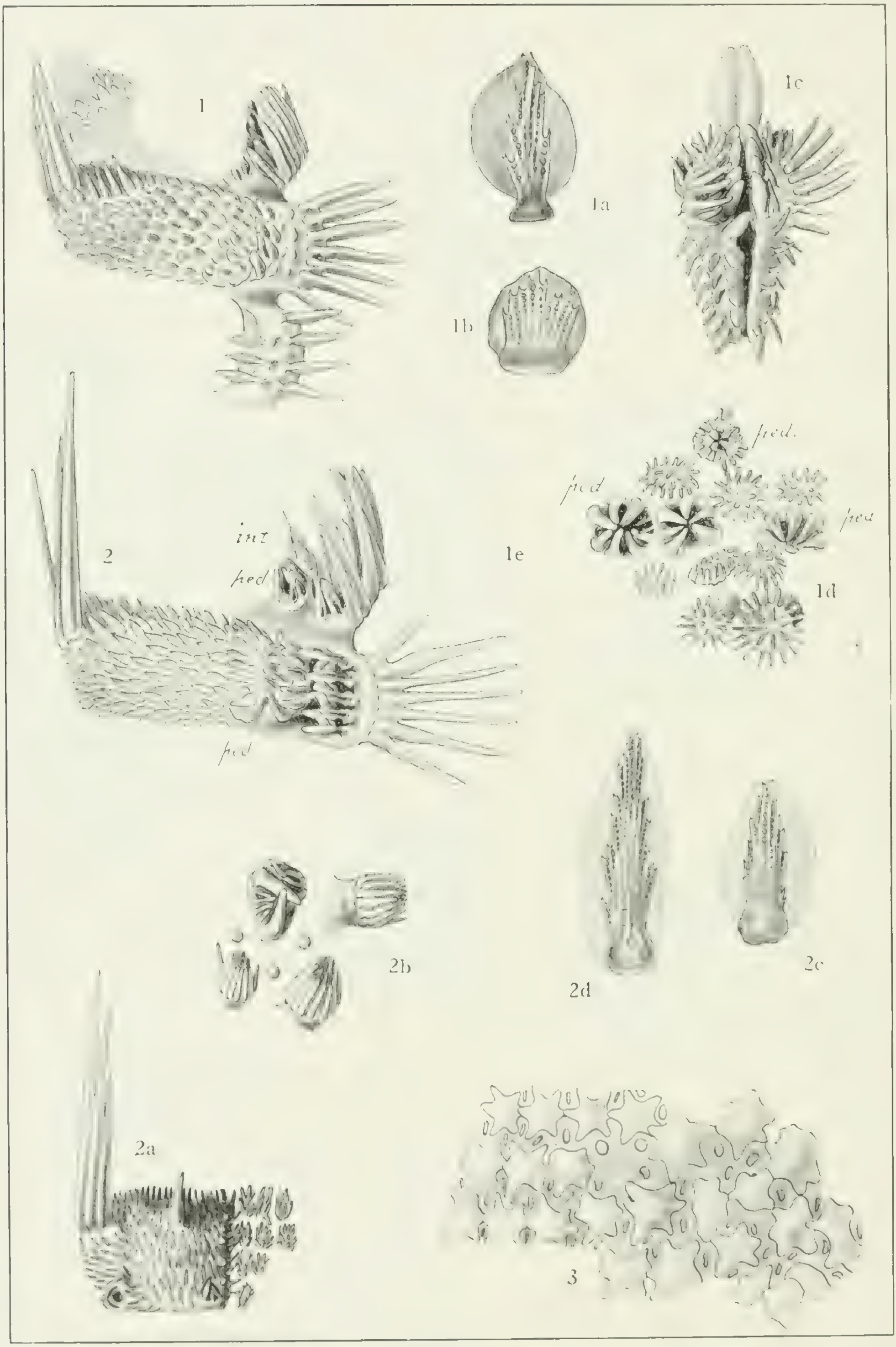
FIG. 1. *Persephonaster tenuis*, type; sixth inferomarginal plate and adjacent actinal intermediate and adambulacral plates, × 4; *ped.*, subambulacral pedicellaria; *int.*, intermediate plate. 1*a*. Same; 2 paxillae from near radial line, base of ray, × 16; *ped.*, pedicellaria with 4 jaws; papulae outlined by circles. 1*b*. Same, terminal plate, × 6.5; two superomarginal plates are shown (*sup.*). 1*c*. Same; inferomarginal spinelet from outer half of plate, × 52. 1*d*. Same; inferomarginal spinelet from near inner edge of plate, × 52. P. 121.

2. *Persephonaster multicinctus*, type; eighth and ninth adambulacral plates, × 6.5; the furrow spines of the eighth plate have been removed and the inner subambulacrals bent toward furrow. 2*a*. Same; paxillae and pedicellariae from disk, × 16; *ped.*, pedicellaria; *pap.*, papula. 2*b*. Same; a spinelet from near middle of inferomarginal plate, × 52. 2*c*. Same; a spinelet from near inner edge of inferomarginal plates. P. 123.

3. *Persephonaster monostoechus*, type; two proximal inferomarginal plates, and adjacent actinal intermediate (*int.*) and adambulacral plates, × 6.5. 3*a*. Same; 3 paxillae, and a pedicellaria, × 16. 3*b*. Same; a paxilla seen from the side, × 16. 3*c*. Same; 2 inferomarginal spinelets, × 52. P. 134.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 38.

FIG. 1. *Persephonaster suluensis*, type; seventh and part of eighth inferomarginals, with adjacent actinal intermediate and adambulacral plates, × 6.5. 1*a*. Same; spinelet from inner edge of inferomarginal plate, × about 48. 1*b*. Same; spinelet from outer part of plate, × 40. 1*c*. Same; mouth plates, × 6.5. 1*d*. Same; paxillae and pedicellariae from base of ray, × 16; *ped.*, pedicellariae. 1*e*. Same; paxilla, from side, × 16. P. 125.

2. *Persephonaster oediplax*, type; sixth inferomarginal plate and adjacent actinal intermediate (*int.*) and adambulacral plates, × 6.5; *ped.*, pedicellaria. 2*a*. Same; thirteenth superomarginal and upper end of adjacent inferomarginal plate, × 6.5. 2*b*. Same; four paxillae from radius, base of ray; one shows a pedicellarian apparatus, × 16. 2*c*. Same; inferomarginal spinelet from outer part of plate, × 52. 2*d*. Same; inferomarginal spinelet from near inner edge of plate, × 52. P. 127.

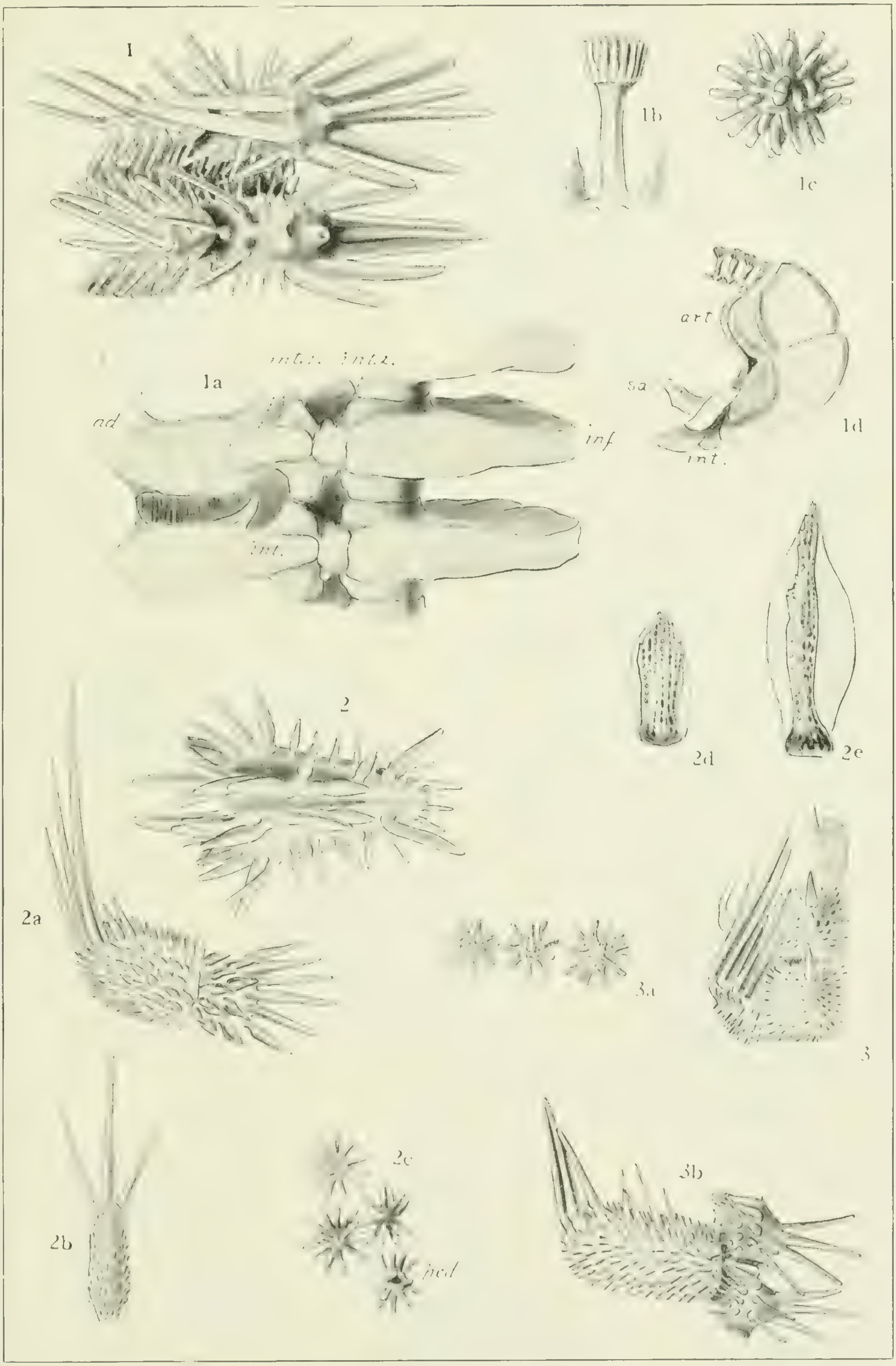
3. *Anthosticte aulophora*, type; abactinal plates from coelomic side, × 8. The irregular plates on the right are in the median radial region of the ray, and those to the left are in regular transverse series, p. 140.

Plate 39.

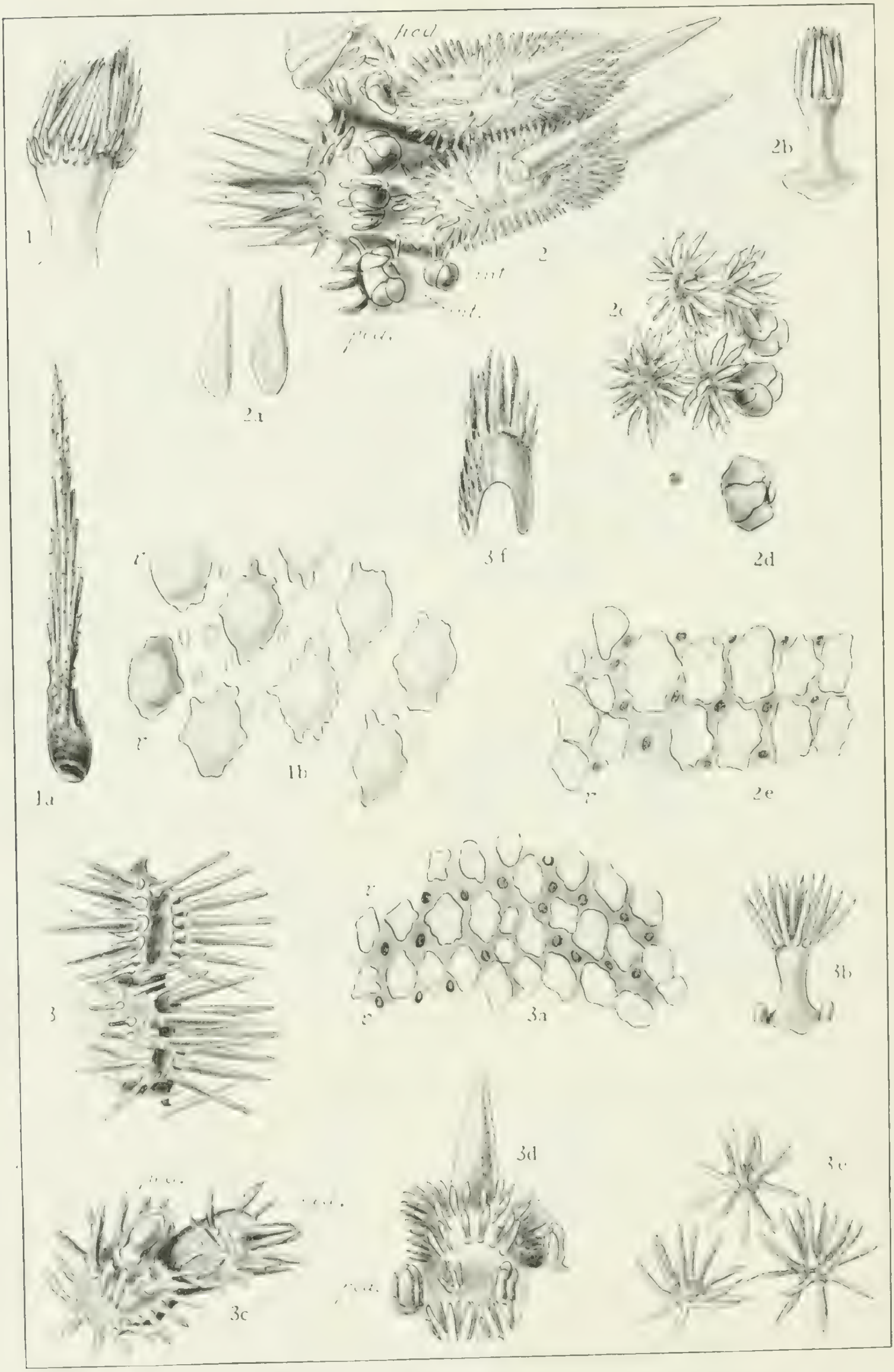
Fig. 1. *Anthosticte aulophora*, type; nineteenth and twentieth adambulacral plates, with adjacent actinal intermediate plates to the left, × 6.5. 1*a*. Same; three inferomarginal (*inf.*) and adjacent actinal intermediate (*int.* 1, *int.* 2) and adambulacral plates (*ad.*) to show the deep marginal fasciolar channels, × 6.5 1*b*. Same; paxilla from side, × 8. 1*c*. Paxilla from base of ray with three pedicellariae, × 8. 1*d*. Same; adoral face of a pair of marginal plates, showing the full height of their specialized ridges, × 4. *Art.*, articulating surface of superomarginal; *sa.*, superambulacral plate; *int.*, actinal intermediate plates. P. 140.

2. *Persephonaster habrogenys*, type; mouth plates × 8. 2*a*. Same; eleventh inferomarginal and adjacent adambulacral plate, × 8. 2*b*. Same; terminal plate, × 8. 2*c*. Same; paxillae from lateral portion of area, base of ray; *ped.*, pedicellaria, × 16. 2*d*. Same; spinelet from middle of inferomarginal plate, × 52. 2*e*. Same; spinelet from near furrow margin of inferomarginal plate, × 52. P. 131.

3. *Tritonaster crorus*, type; eighth to tenth superomarginal, and upper end of eighth inferomarginal, showing lateral spines, × 8. 3*a*. Same; three paxillae from disk, × 16. 3*b*. Same; fifth inferomarginal and 2 adjacent adambulacral plates, × 8. P. 136.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 40.

FIG. 1. *Dipsacaster imperialis*, type; abactinal paxilla, from side, × 8. 1*a*. Same; paxillar spinelet much enlarged; compare with *D. diaphorus*. 1*b*. Same; abactinal plates, × 8; *r—r*, radial line. P. 146.

2. *Koremaster evaulus*, type; sixth and seventh inferomarginal plates, and adjacent actinal intermediate (*int.*) and adambulacral plates, showing pedicellariae (*ped.*), × 6.5. 2*a*. Same; two furrow spines, side view × 6.5. 2*b*. Same; side view of paxilla, × 12. 2*c*. Same; paxillae from near edge of paxillar area, with characteristic pedicellariae, × 12. 2*d*. Same; a pedicellaria from edge of paxillar area, × 12. 2*e*. Same; abactinal plates from ray, × 12; *r—r*, radial line. P. 157.

3. *Koremaster evaulus spiculatus;* fifth and sixth adambulacral plates, × 6.5. 3*a*. Same; abactinal plates, × 12; *r—r* radial line. 3*b*. Same; side view of paxilla from near radial line, disk, × 12. 3*c*. Same, two actinal intermediate plates opposite second adambulacral showing pedicellariae (*ped.*), × 12. 3*d*. Same; second superomarginal plate, from above, showing the adjacent margin of paxillar area, and 3 pedicellariae (*ped.*) belonging thereto, along with 3 paxillae, × 12. 3*e*. Same; paxillae from interradial region of disk, × 12. 3*f*. Same; terminal plate, × 6.5; spinelets removed from right half. P. 161.

Plate 41.

Fig. 1. *Dipsacaster imperialis*, type; seventh adambulacral plate, enlarged. 1*a*. Same; mouth plates with spines removed for comparison with fig. 2, × 3.2. P. 146.

2. *Dipsacaster nesiotes*, station 5624; mouth plates with spines removed, × 3.2. P. 145.

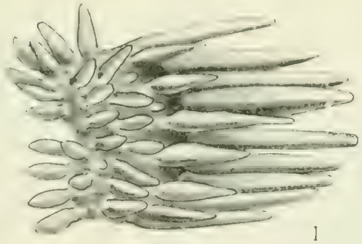
3. *Dipsacaster diaphorus*, type; sixth inferomarginal and adjacent adambulacral plates, × 9.6. 3*a*. Same; side view of a paxilla from near the base of ray, × 16. 3*b*. Same; abactinal paxillae, × 16. 2*c*. Same; abactinal plates from inner or coelomic side, × 8. P. 152.

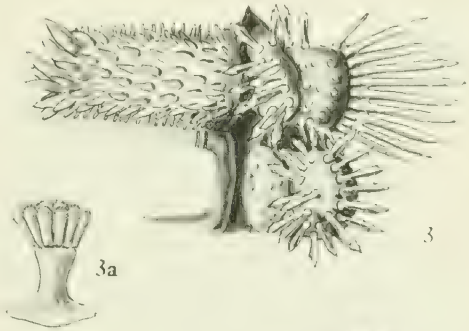
4. *Patagiaster sphaerioplax*, type; fourth inferomarginal plate and adjacent actinal and adambulacral plates; *int.*, actinal intermediate plates, × 8. 4*a*. Same; abactinal paxilla from vicinity of madreporic body, × 16. P. 154.

5. *Luidia prionota*, type, sixth inferomarginal and adjacent ninth adambulacral plates, × 12. 5*a*. Same; twelfth adambulacral plate from adoral side, × 12. P. 164.

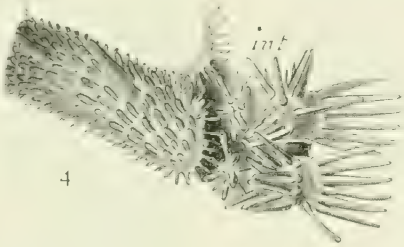
6. *Radiaster notabilis*, type; paxillae from midradial region, at base of ray, × 12. 6*a*. Same; the tenth adambulacral plate, and an adjacent actinal intermediate plate, × 6.5. P. 217.

7. *Tarachaster tenuis*, type; abactinal plates, ray near base; plates to left of dotted line in the region of regularly arranged plates, × 12. 7*a*. Same; adambulacral plates at base of ray, × 12. P. 402.

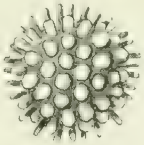

1

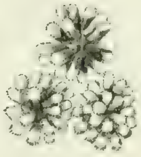

3

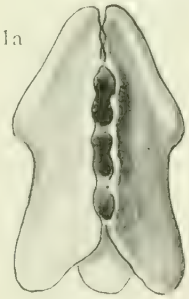
3a

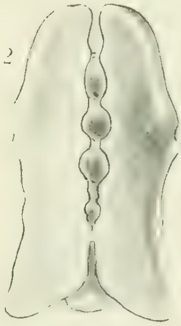


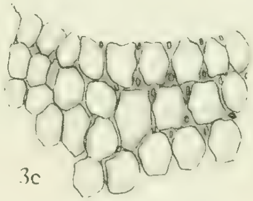
4

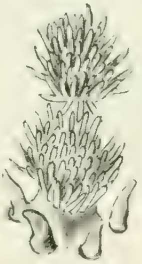

4a

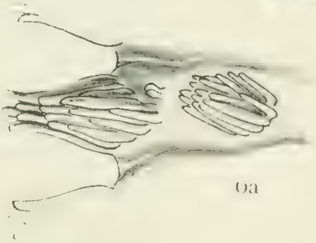

3b

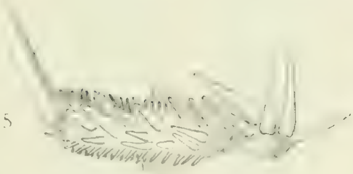

1a


2

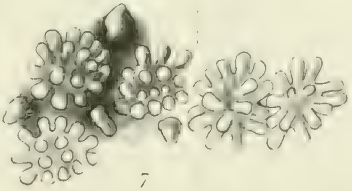

3c

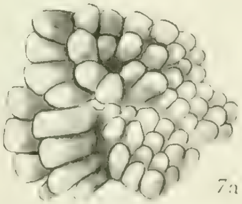

6


6a

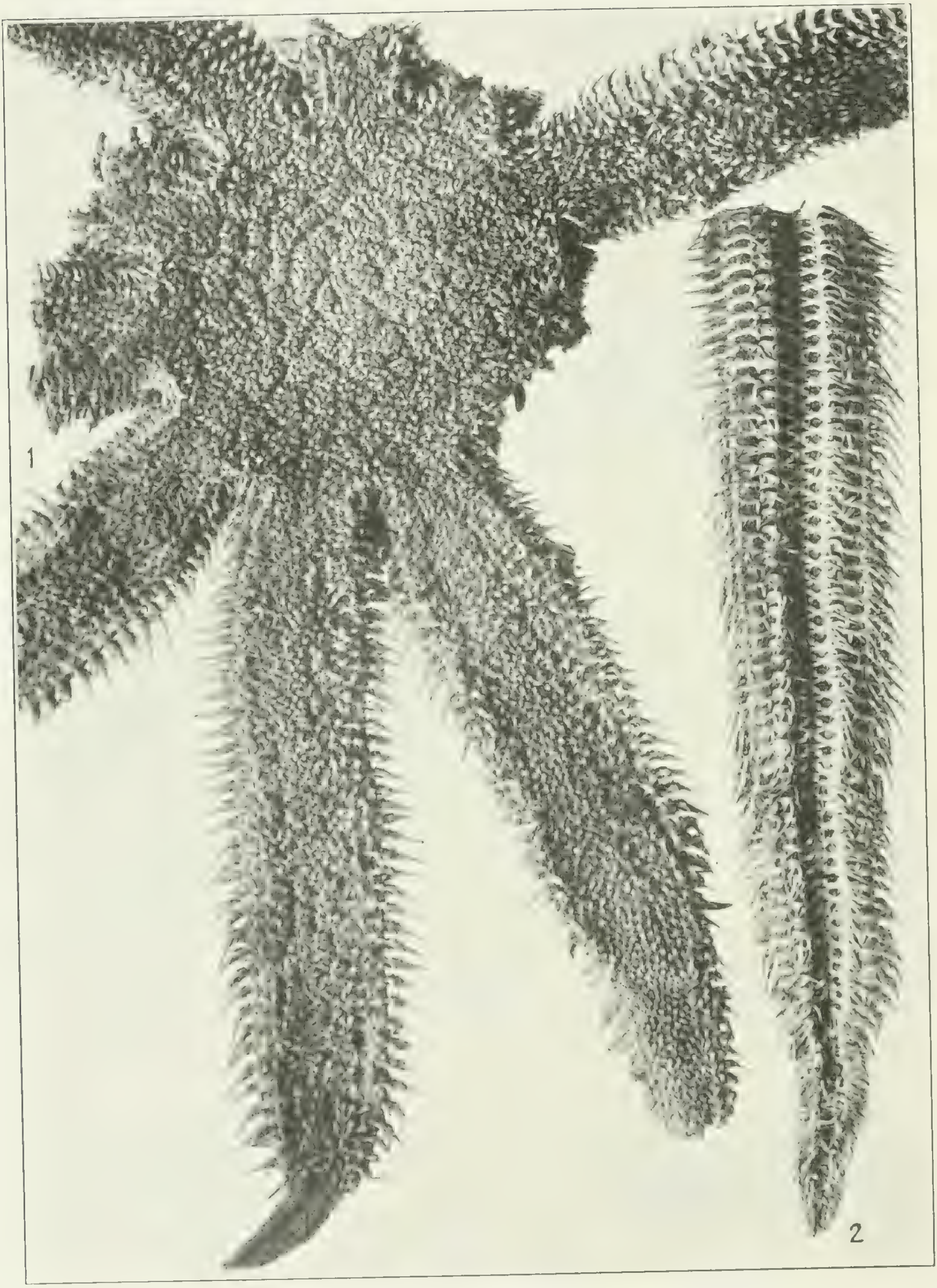

5

5a


7


7a

Starfishes of the Philippine Seas and Adjacent Waters.



Starfishes of the Philippine Seas and Adjacent Waters.

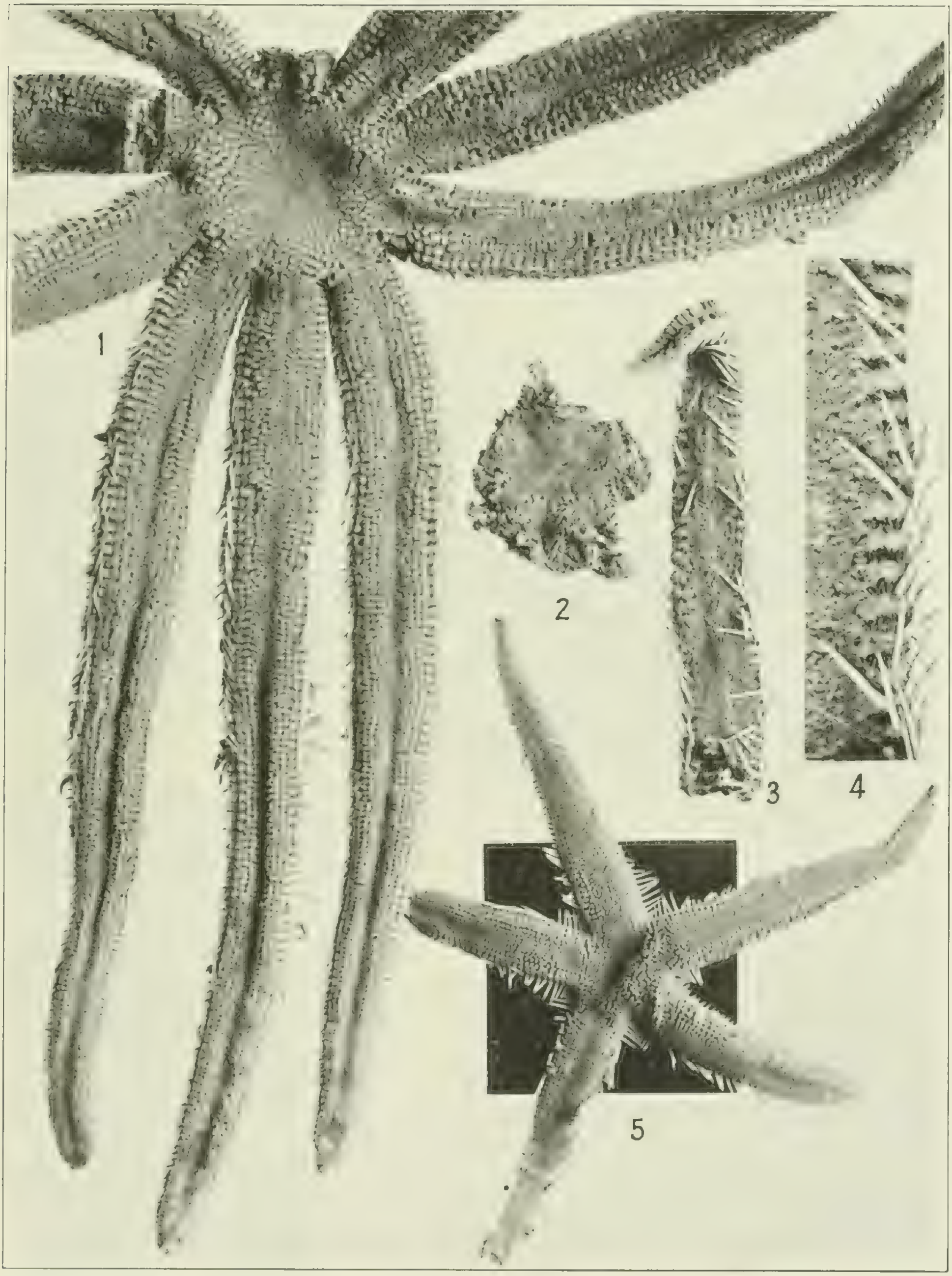
PLATE 42.

Luidia gymnochora, type.

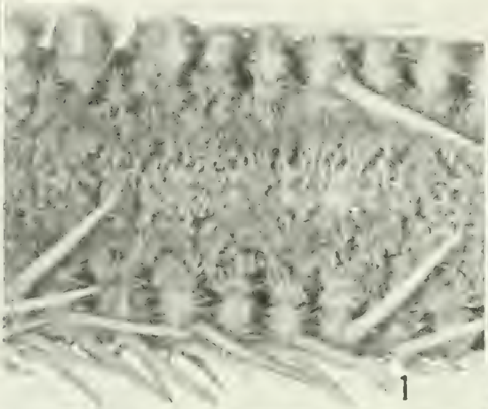
FIG. 1. Abactinal surface, p. 175.
2. Actinal surface of one ray, dried, p. 175.

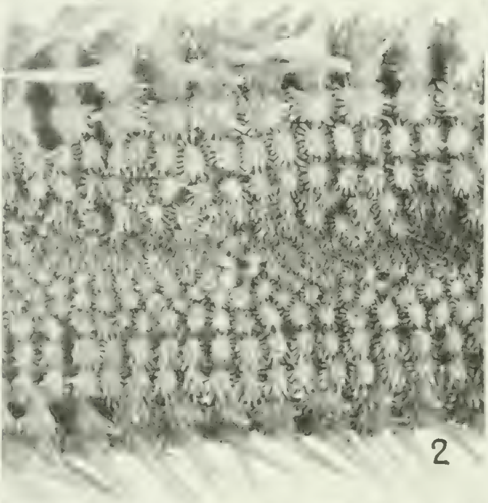
PLATE 43.

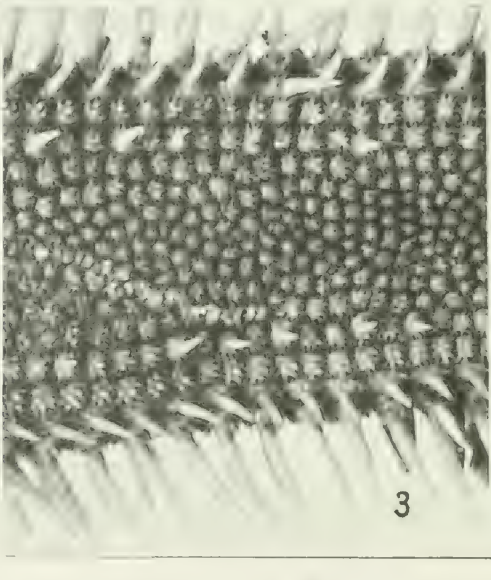
FIG. 1. *Luidia avicularia;* abactinal aspect of type, reduced, p. 172.
2. *Luidia orientalis;* type. Disk with all 5 rays removed, p. 166.
3. Same; one ray, same as disk; abactinal view.
4. Same; margin of abactinal area of ray much enlarged.
5. *Luidia longispina;* abactinal view, p. 164.

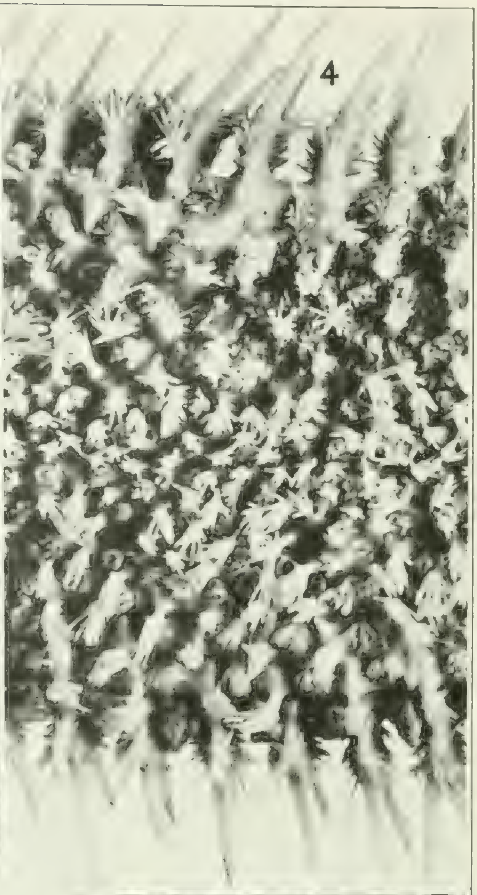


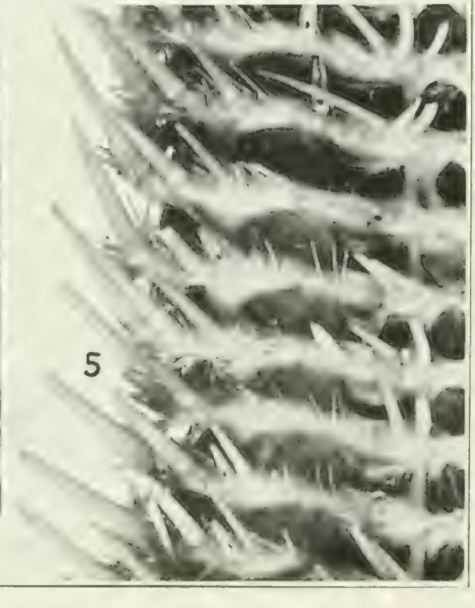
Starfishes of the Philippine Seas and Adjacent Waters.


1


2


3


4


5

Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 44.

FIG. 1. *Luidia orientalis;* portion of abactinal surface of ray, enlarged, p. 166.

2. *Luidia avicularia;* portion of abactinal surface of ray, enlarged, p. 172.

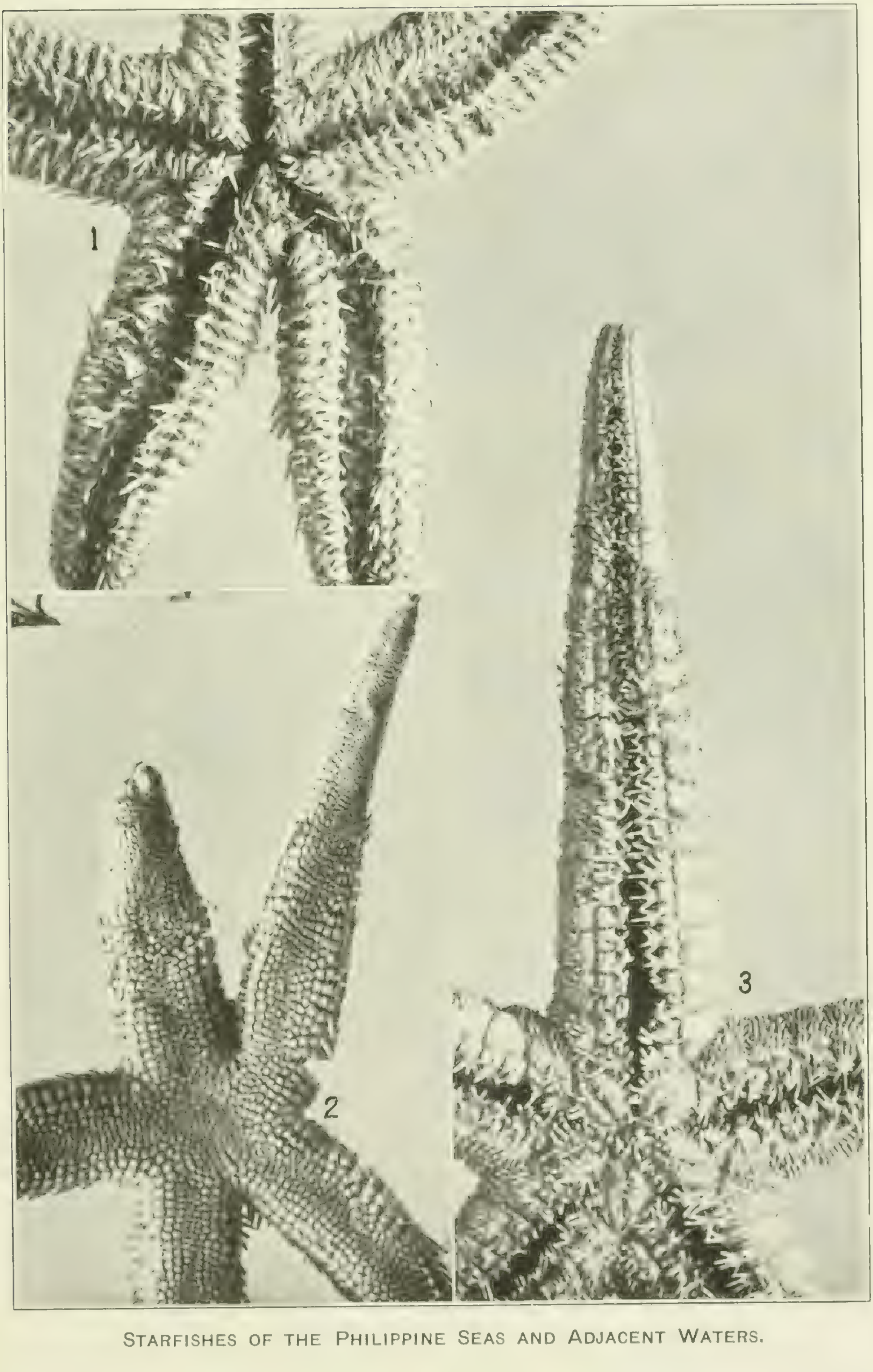
3. *Luidia moroisoana;* portion of ray of a specimen from Japan, for comparison with *L. avicularia* (fig. 2); enlarged, p. 175.

4. *Luidia gymnochora;* portion of abactinal surface of ray, enlarged, p. 175.

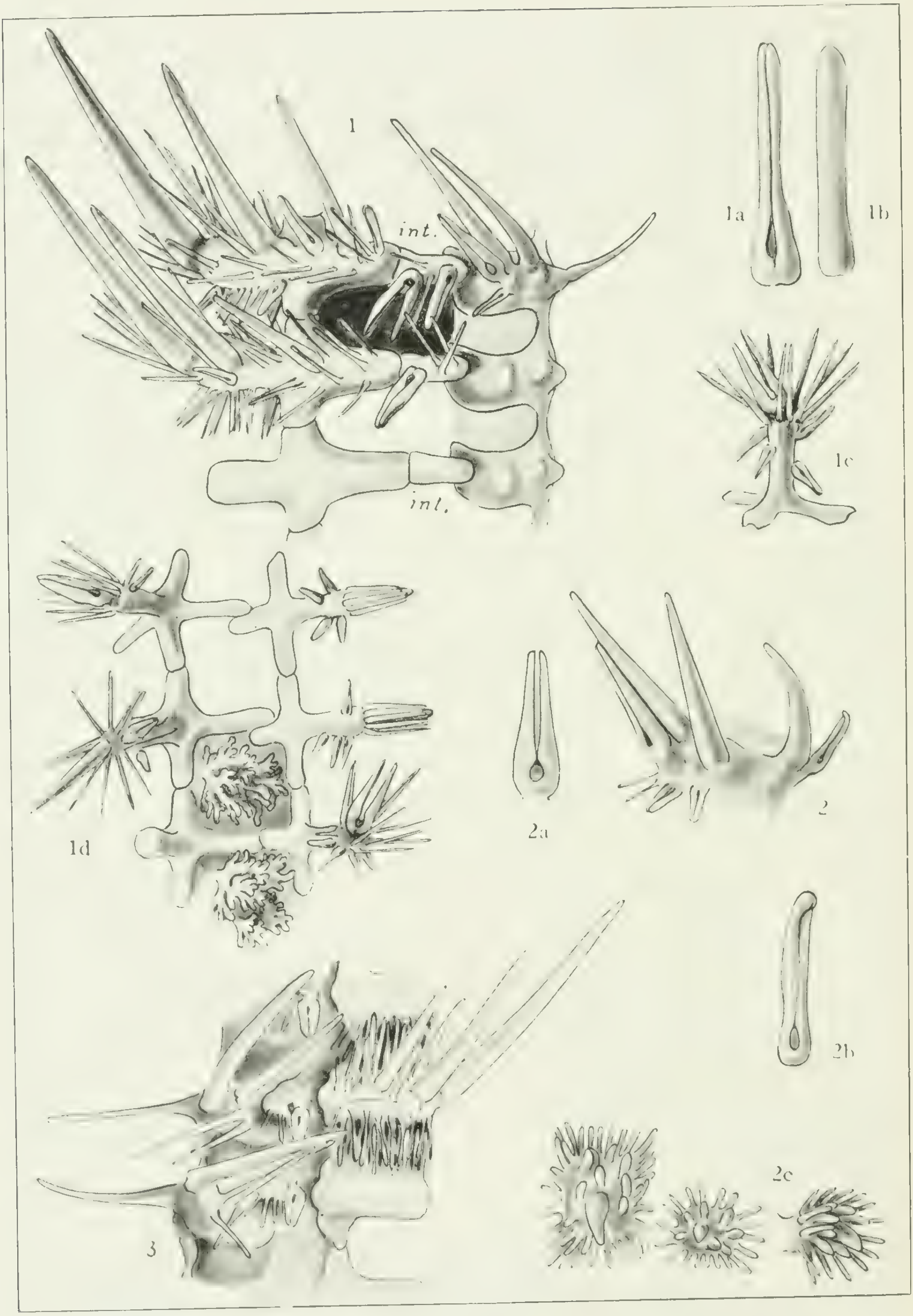
5. Same; one-half of an enlarged view of actinal surface of ray; further on the right.

PLATE 45.

FIGS. 1, 2. *Luidia prionota;* type, actinal and abactinal view, enlarged, p. 164.
3. *Archaster angulatus;* actinal view, enlarged, p. 181.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 46.

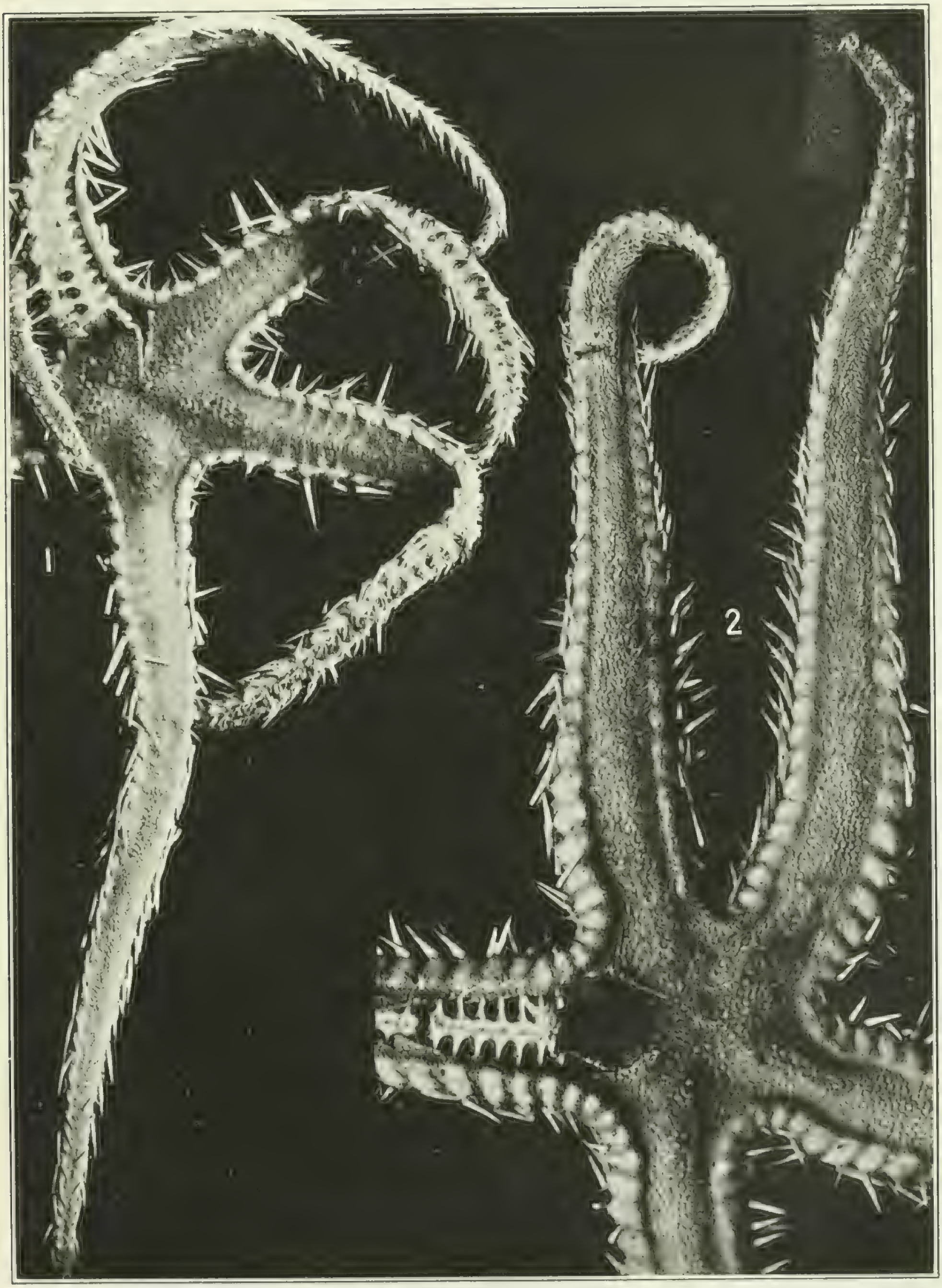
Fig. 1. *Luidia gymnochora*, type; inferomarginal, intermediate, and adambulacral plates at about the end of the proximal third of ray; the proximal plates of the 3 segments denuded of spines; *int.*, actinal intermediate plates, × 4. 1*a*. Same; furrow pedicellaria from third adambulacral plate, ventral aspect (the valves are lateral, not dorsal and ventral). 1*b*. Same pedicellaria as 1*a*, aboral valve, outer face, × 16. 1*c*. Same; side view of a superomarginal paxilla near base of ray, × 6.5. 1*d*. Same; the right-hand series of abactinal paxillae are adjacent to the superomarginal paxillae; 2 papulae are shown (*p.*), × 6.5. P. 175.

2. *Luidia avicularia*, type; eighteenth adambulacral plate, × 8. 2*a*. Same; subambulacral pedicellaria, × 8. 2*b*. Same; aboral aspect of a furrow pedicellaria, the actinal jaw to the right, × 16. 2*c*. Same; superomarginal (left) and paxillae of next 2 longitudinal series, end of proximal third of ray. P. 172.

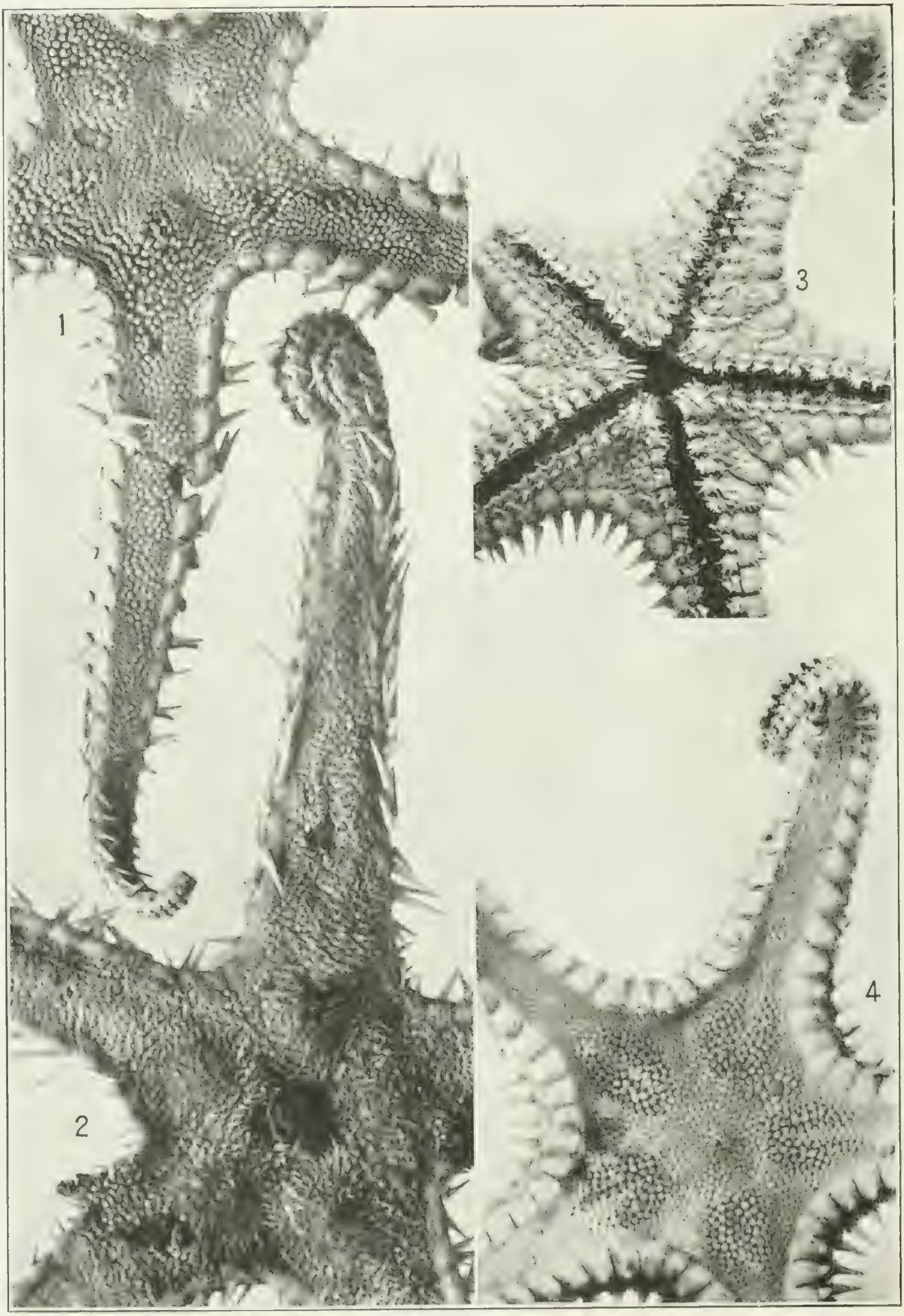
3. *Luidia orientalis*, type; eighth and ninth adambulacral, and adjacent actinal and inferomarginal plates, × 6.5. P. 166.

PLATE 47.

FIG. 1. *Cheiraster diomedeae;* abactinal aspect of type, p. 200.
2. *Cheiraster niasicus;* abactinal aspect, p. 192.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 48.

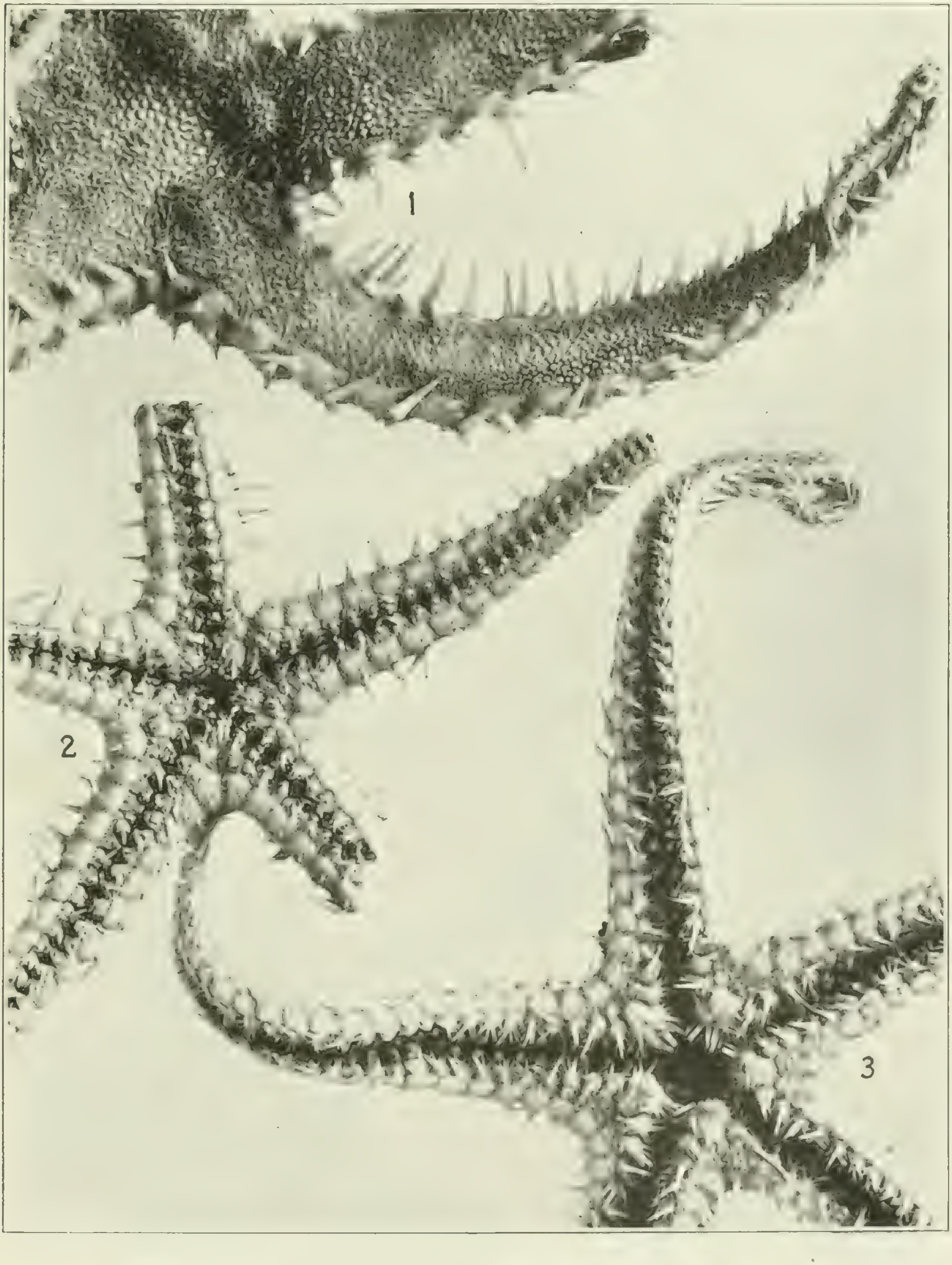
FIG. 1. *Cheiraster ludwigi;* abactinal view of type, enlarged, p. 203.
2. *Pectinaster hylacanthus;* abactinal view of type, enlarged, p. 187.
3. *Cheiraster triplacanthus;* actinal view of type, enlarged, p. 205.
4. Same; abactinal view of type, enlarged, p. 205.

Plate 49.

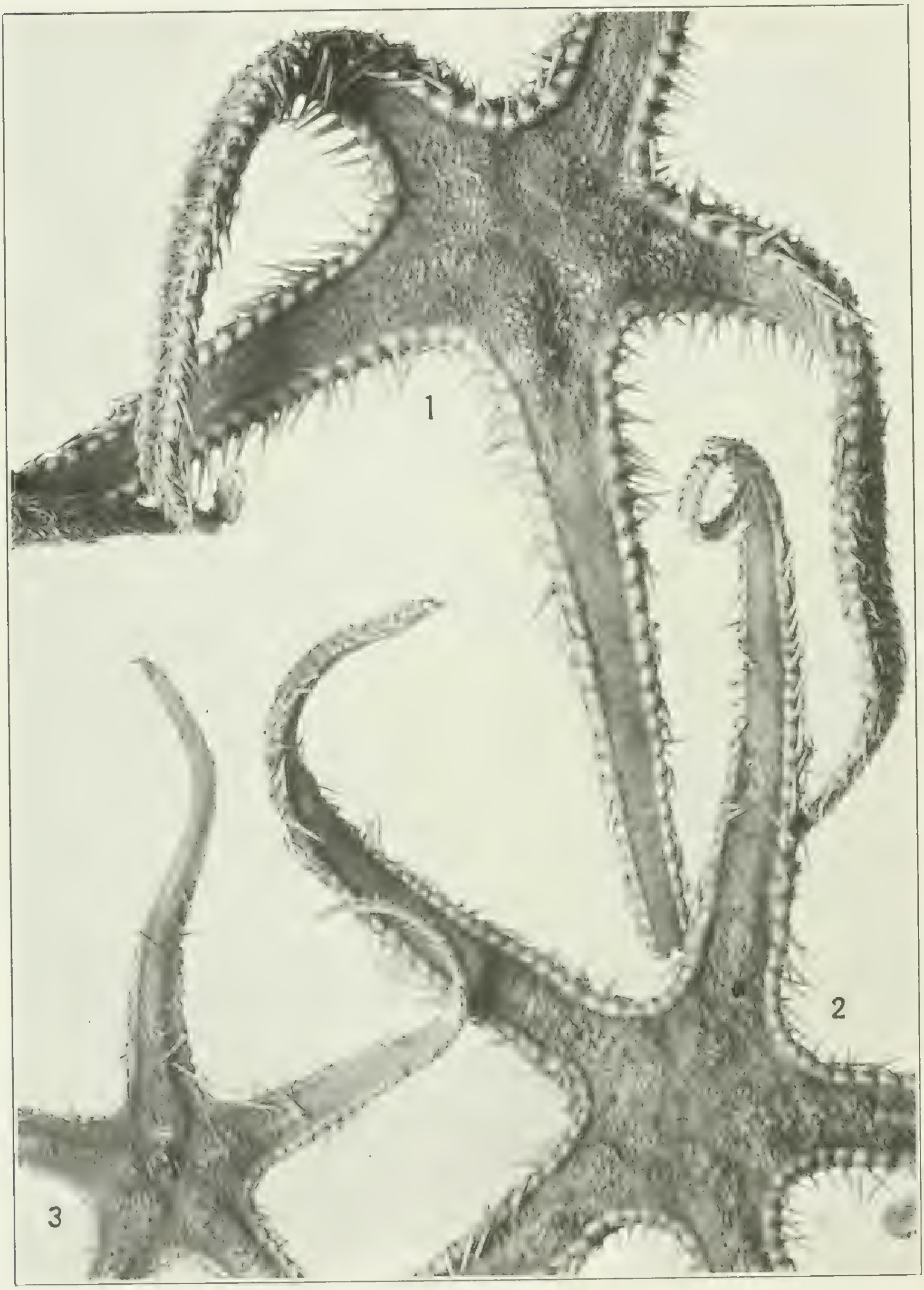
Fig. 1. *Pectinaster mimicus;* abactinal aspect of specimen from station 5630, enlarged, p. 182.

2. *Cheiraster ludwigi;* type, actinal aspect, enlarged, p. 203.

2. *Cheiraster ludwigi;* type, actinal aspect, enlarged, p. 203.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 50.

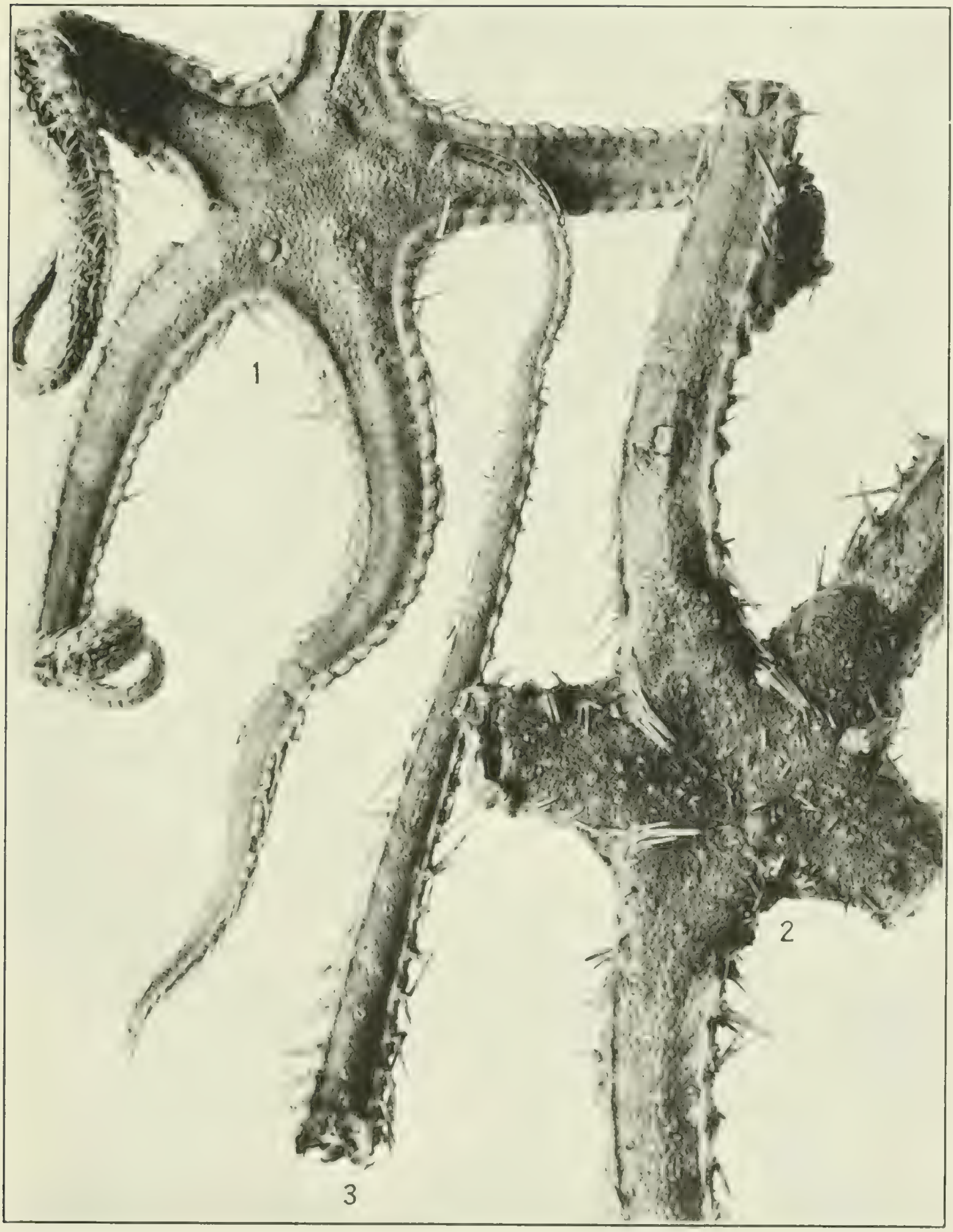
Cheiraster gazellae.

FIGS. 1 and 2. Abactinal view of 2 large specimens, p. 196.
FIG. 3. Abactinal surface of small specimen with very numerous abactinal pedicellariae.

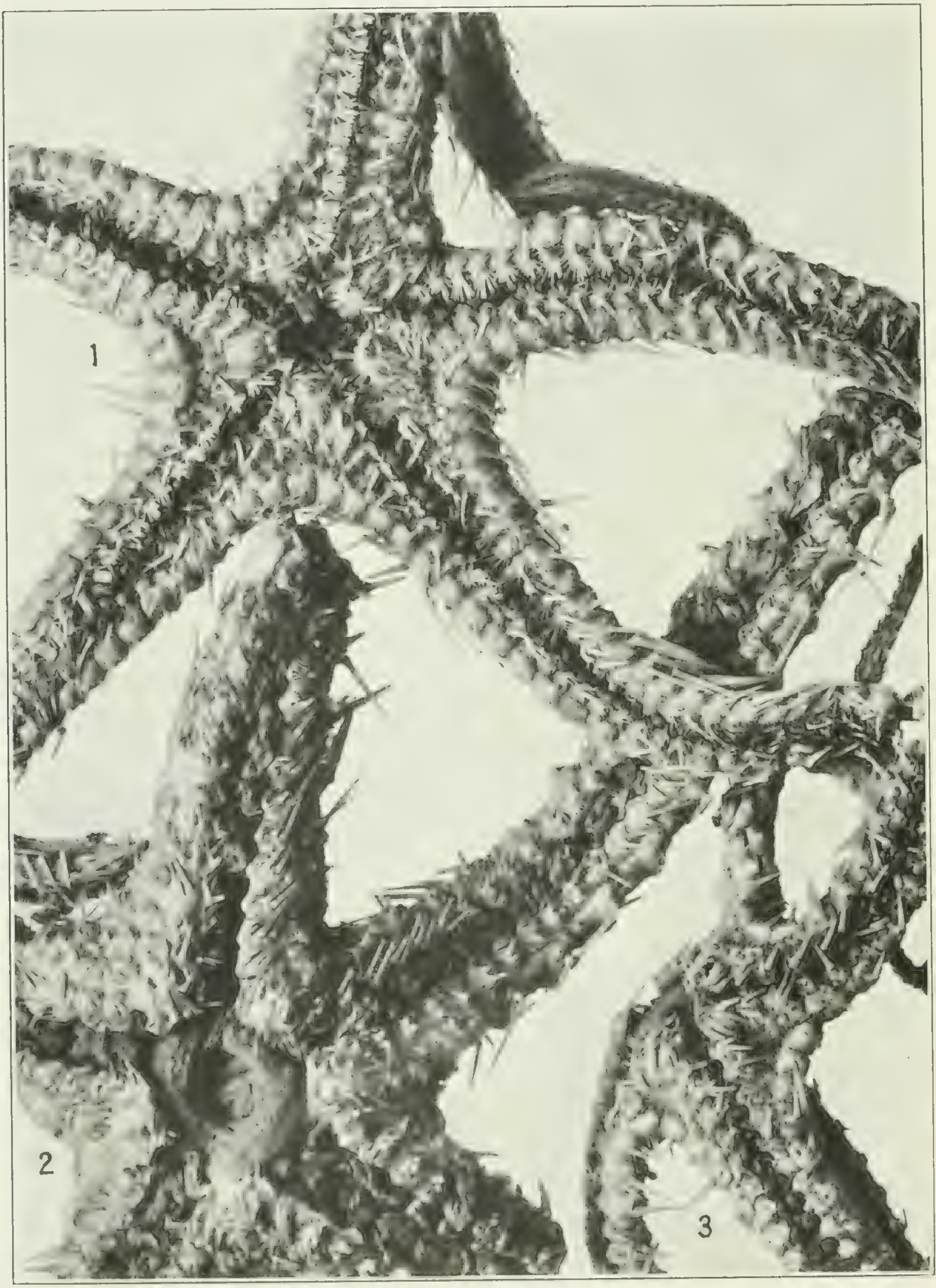
Plate 51.

Fig. 1. *Cheiraster gazellae;* abactinal view of a large specimen upon which description is based, p. 196.

2, 3. *Benthopecten polyctenius;* type, abactinal view, with part of a ray detached, p. 211.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

Plate 52.

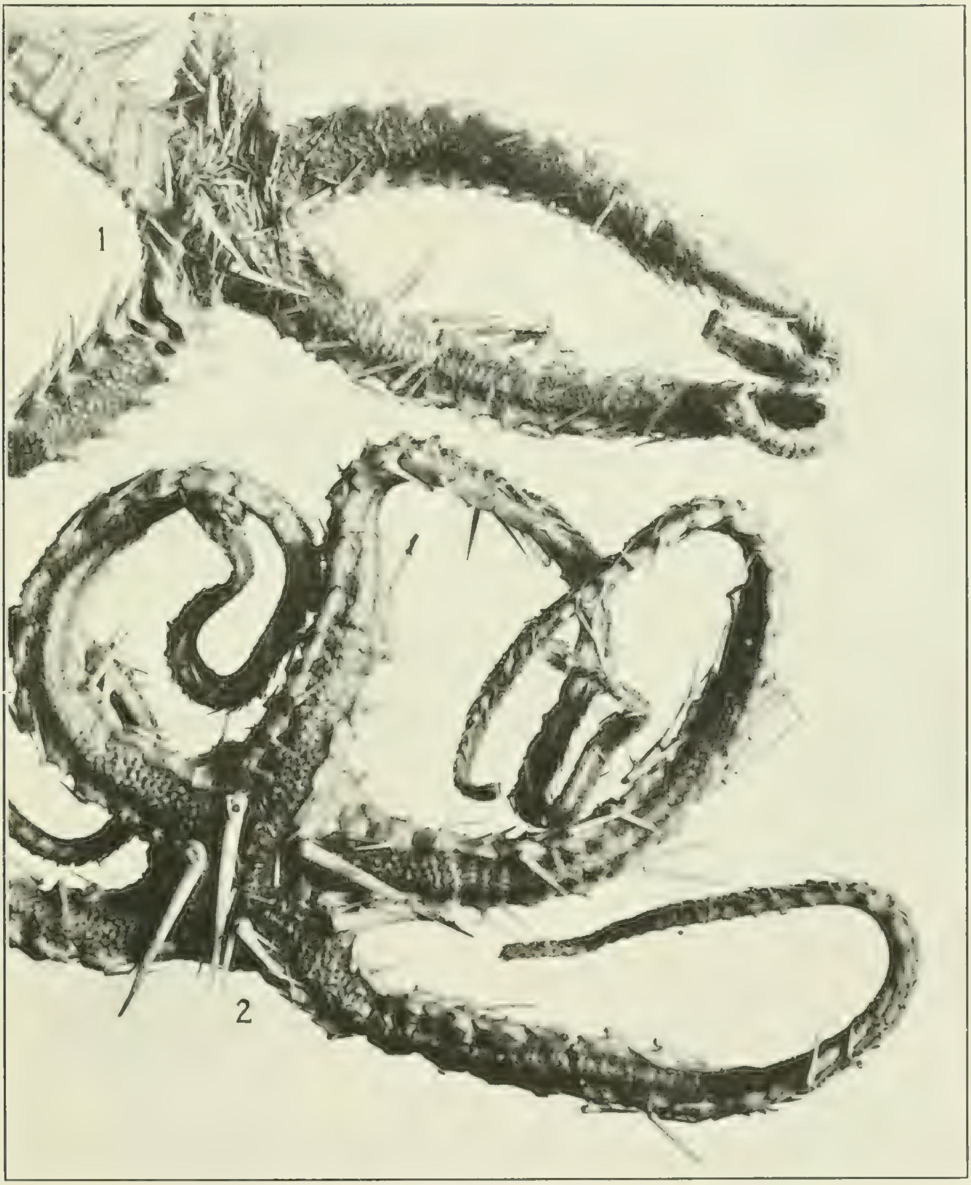
Fig. 1. *Cheiraster gazellae;* actinal view of pl. 51, fig. 1. See p. 196.

2. *Benthopecten polyctenius;* actinal view of type, enlarged, p. 211.

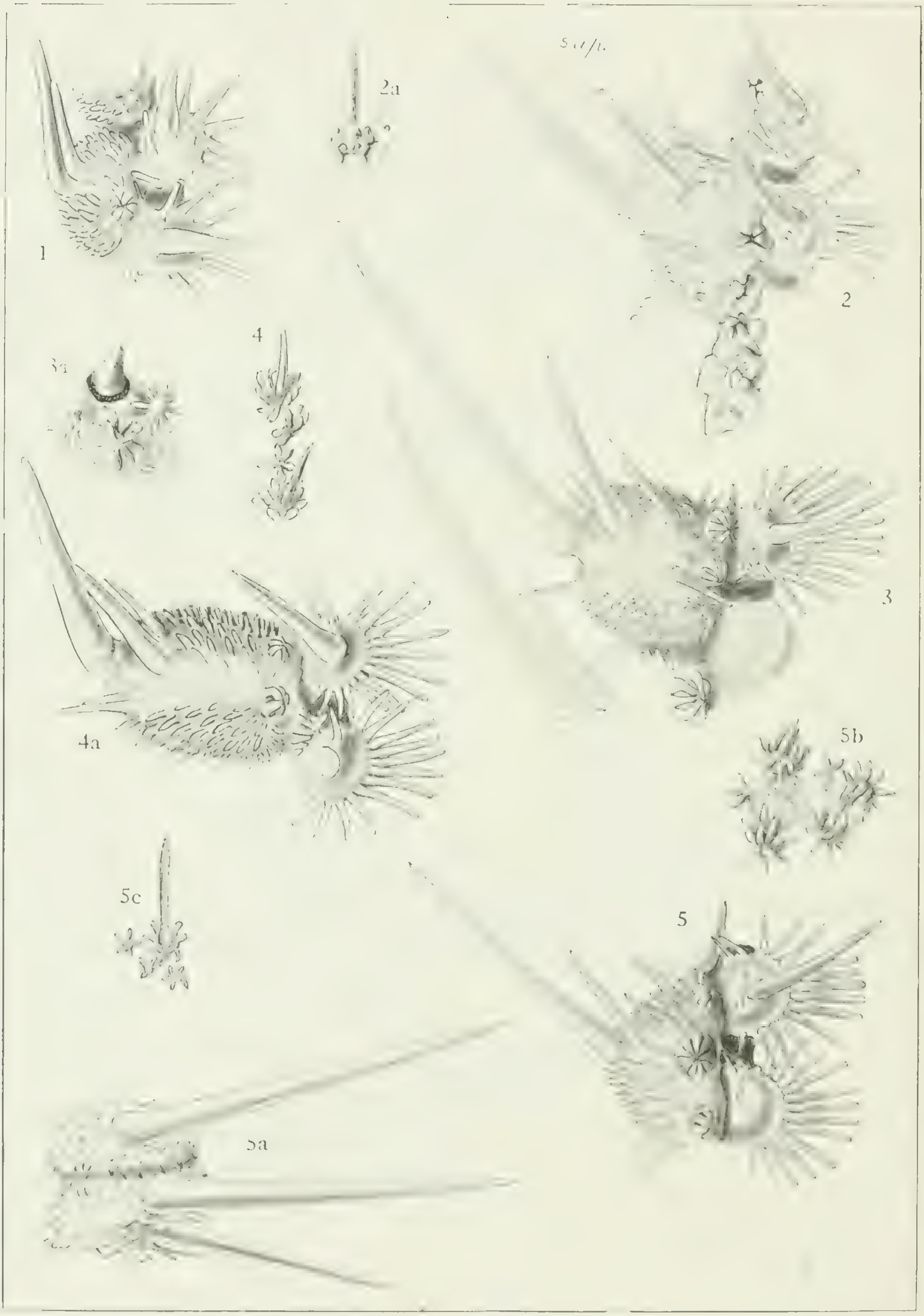
3. *Pectinaster mimicus palawanensis;* actinal aspect of type, enlarged, showing also side of ray, and three-quarter view of actinostome, the inner end of a pair of oral plates, etc., p. 185.

PLATE 53.

FIG. 1. *Benthopecten moluccanus;* abactinal aspect of type, enlarged, p. 208.
2. *Benthopecten styracius;* abactinal aspect of type, enlarged, p. 213.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 54.

FIG. 1. *Pectinaster hylacanthus*, type; fourth and fifth adambulacral, and third and fourth inferomarginal plates. P. 187.

2. *Pectinaster mimicus palawanensis*, cotype; fifth and sixth adambulacral plates and adjacent third and fourth inferomarginal plates; between the latter, a superomarginal plate and spine (*sup.*), × 6.5. 2*a*. Same; abactinal plate and central spinule, from middle of ray of the type, × 16. P. 185.

3. *Cheiraster gazellae;* thirteenth and fourteenth adambulacral, and seventh and eighth inferomarginal plates, × 6.5. 3*a*. Same; paxillae from edge of papularium, × 9.6. P. 196.

4. *Cheiraster niasicus;* abactinal plates or paxillae from midradial line, near base of ray. 4*a*. Same; tenth inferomarginal, and adjacent fourteenth and fifteenth adambulacral plates, × 6.5. P. 192.

5. *Cheiraster diomedeae*, type; fifth inferomarginal, and seventh and eighth adambulacral plates, × 9.6. 5*a*. Same; twelfth superomarginal and adjacent inferomarginal seen from side; note the intermarginal pedicellariae, × 9.6. 5*b*. Same; abactinal paxillae from interradial region of the disk, × 12. 5*c*. Same; abactinal plates from end of second third of ray, × 12. P. 200.

PLATE 55.

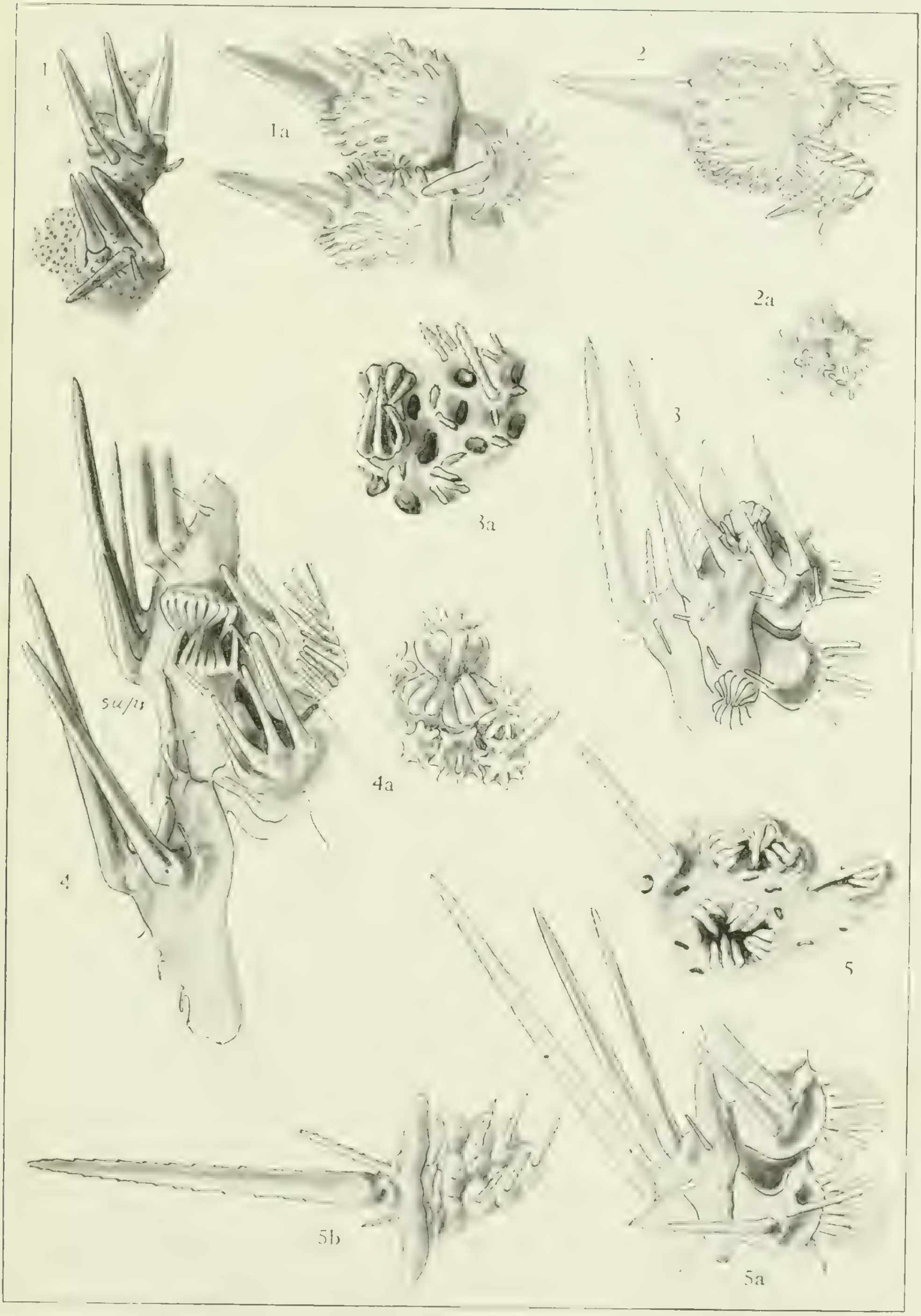
FIG. 1. *Cheiraster triplacanthus*, type; twelfth and thirteenth superomarginal plates showing the transverse series of 3 spines, and (*x*) the enlarged accessory spinule, × 8. 1*a*. Same; fourth and fifth inferomarginal plates, and sixth to eighth adambulacral plates, × 6.5. P. 205.

2. *Cheiraster ludwigi*, type; sixth inferomarginal and ninth and tenth adambulacral plates, × 6.5. 2*a*. Same; abactinal plates, × 9.6. P. 203.

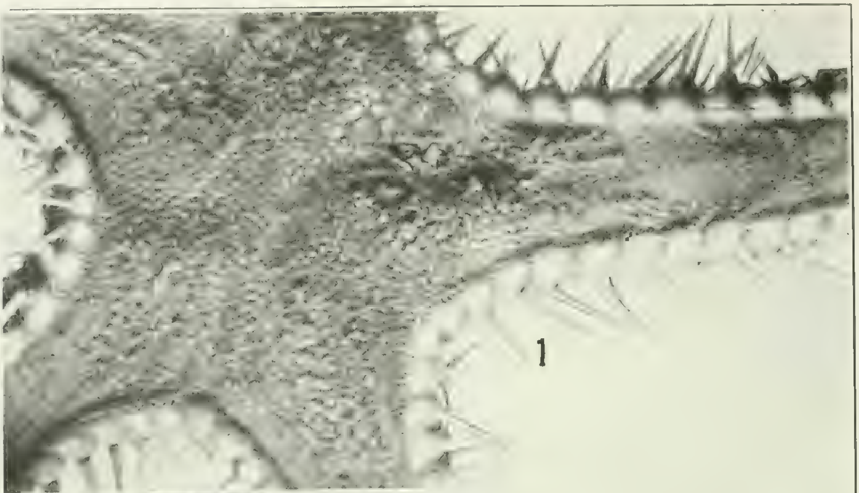
3. *Benthopecten styracius*, type; fourth supero- and inferomarginals, and seventh and eighth adambulacral plates, × 6.5 3*a*. Same; abactinal plates, base of ray, × 9.6. P. 213.

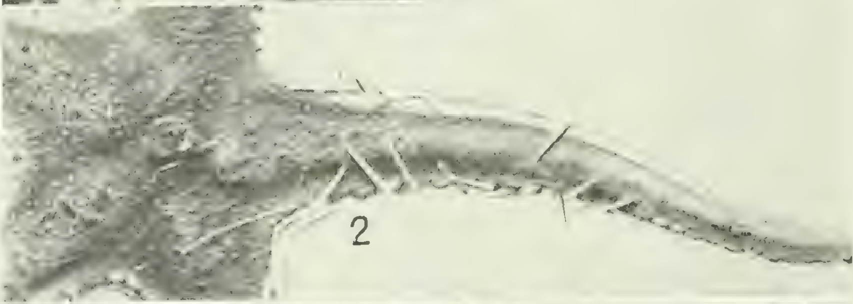
4. *Benthopecten polyctenius*, type; third, fourth, and fifth inferomarginals, the fifth superomarginal (*sup.*), and the eighth and ninth adambulacral plates, the eighth without furrow spines, × 4. 4*a*. Same; abactinal plates, base of ray, midway between two odd interradial superomarginal plates, × 1.6. P. 211.

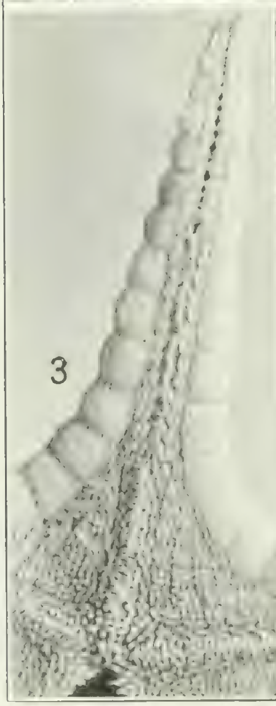
5. *Benthopecten moluccanus*, type; abactinal plates from radial region at base of ray, on a transverse line between 2 odd interradial superomarginals, × 6.5. 5*a*. Same, cotype; third inferomarginal, and sixth and seventh adambulacral plates, × 6.5. 5*b*. Same, type; fourth superomarginal, and adjacent abactinal plates, × 6.5. P. 208.

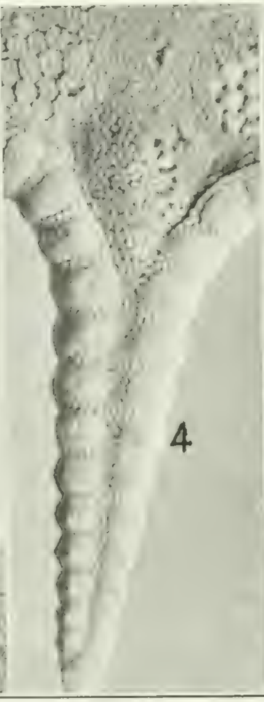


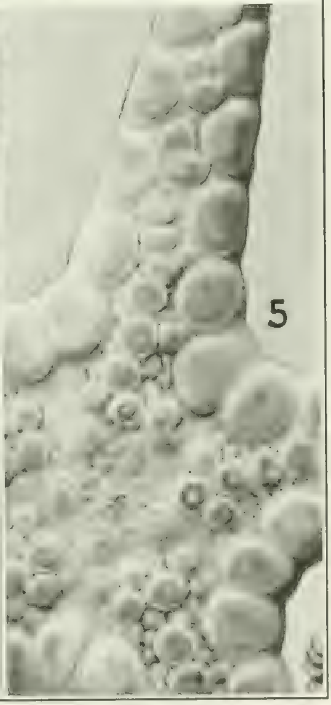
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.


1


2


3


4


5

STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 56.

FIGS. 1, 2. *Cheiraster gazellae;* large and small specimen, enlarged, abactinal view, p. 196.

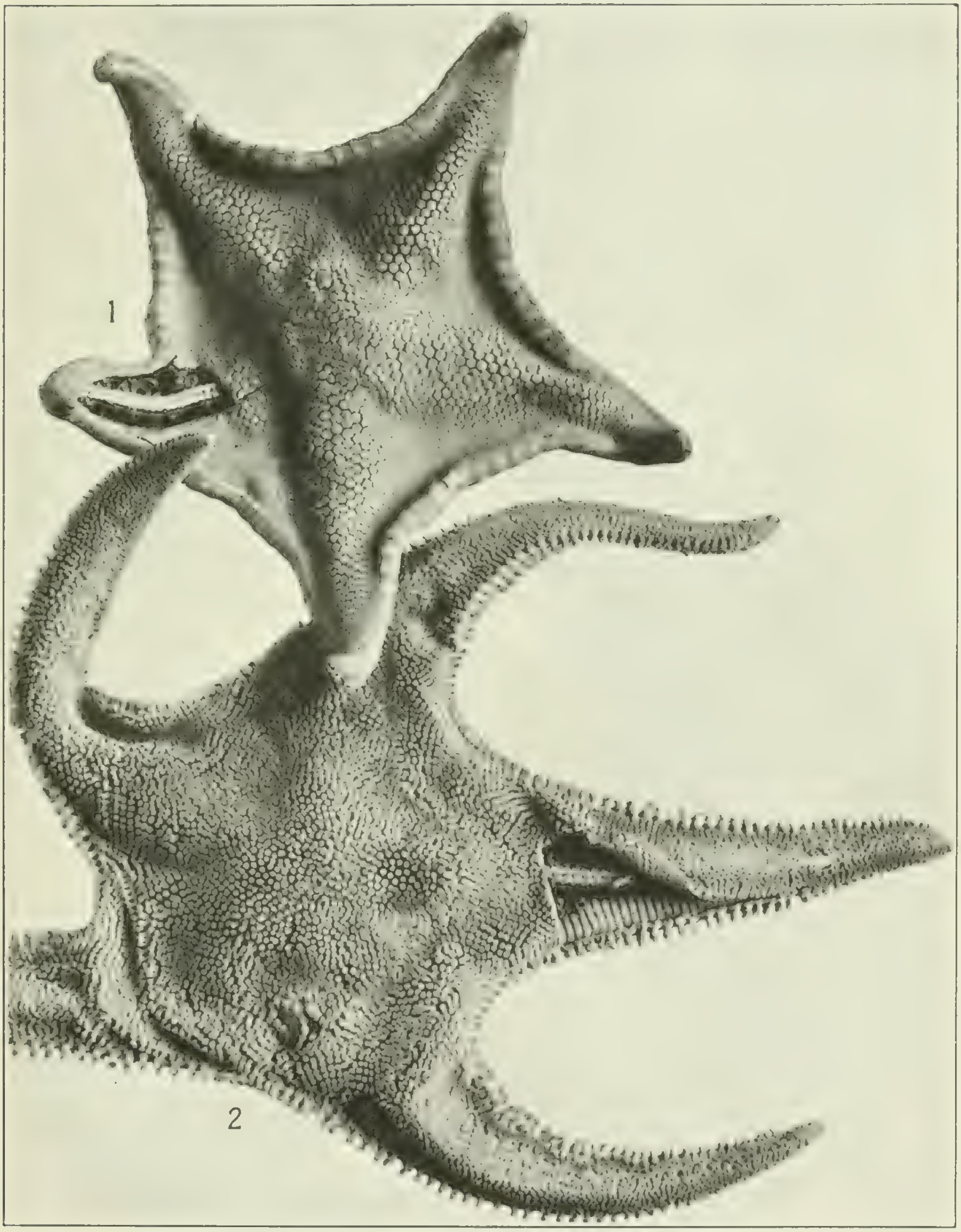
3, 4. *Rosaster mamillatus;* actinal and abactinal views, enlarged, p. 247.

5. *Ferdina glyptodisca;* abactinal view, enlarged, p. 370.

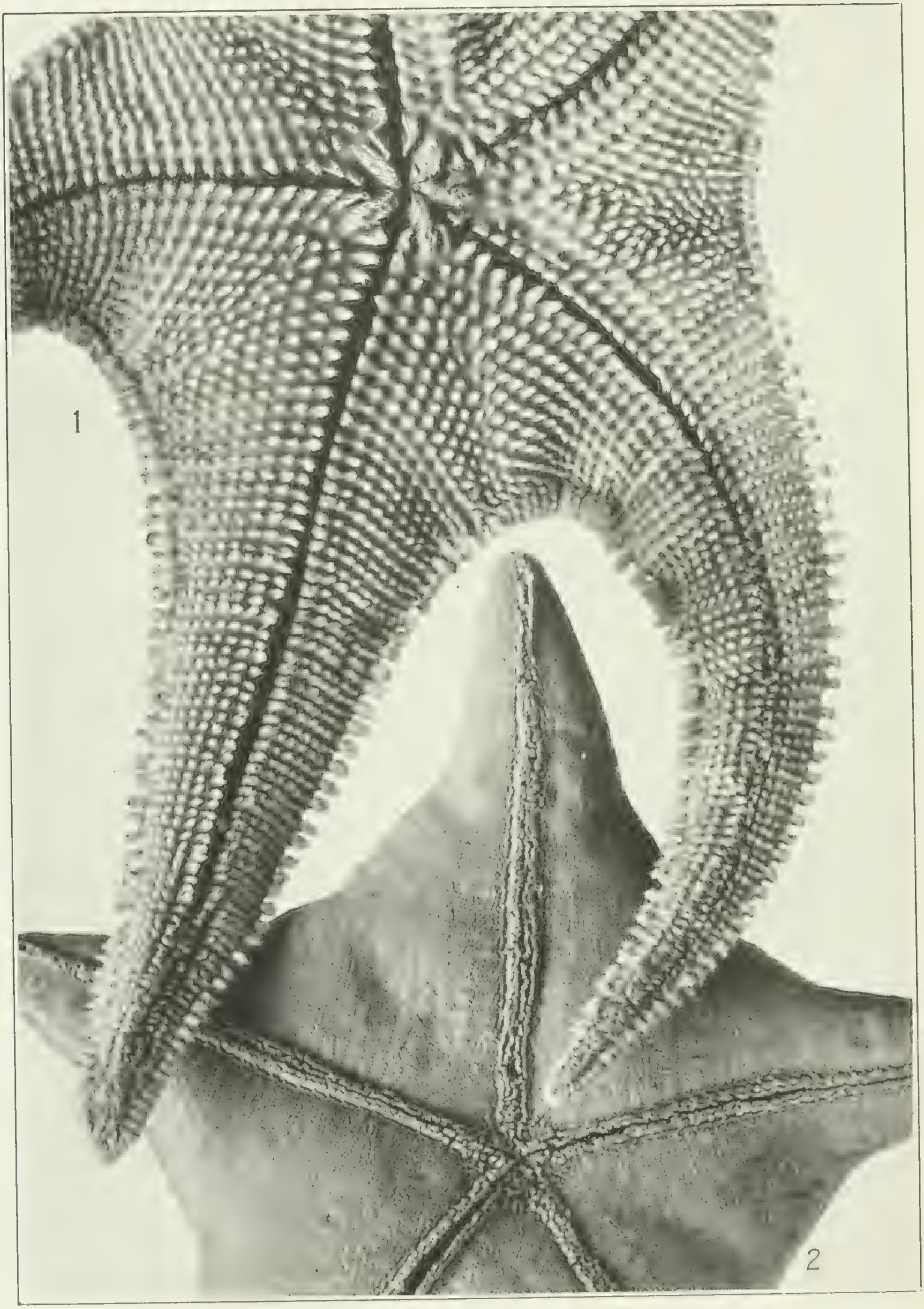
PLATE 57.

FIG. 1. *Ceramaster smithi;* abactinal view of type, p. 257.

2. *Radiaster notabilis;* abactinal view of type, p. 217.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

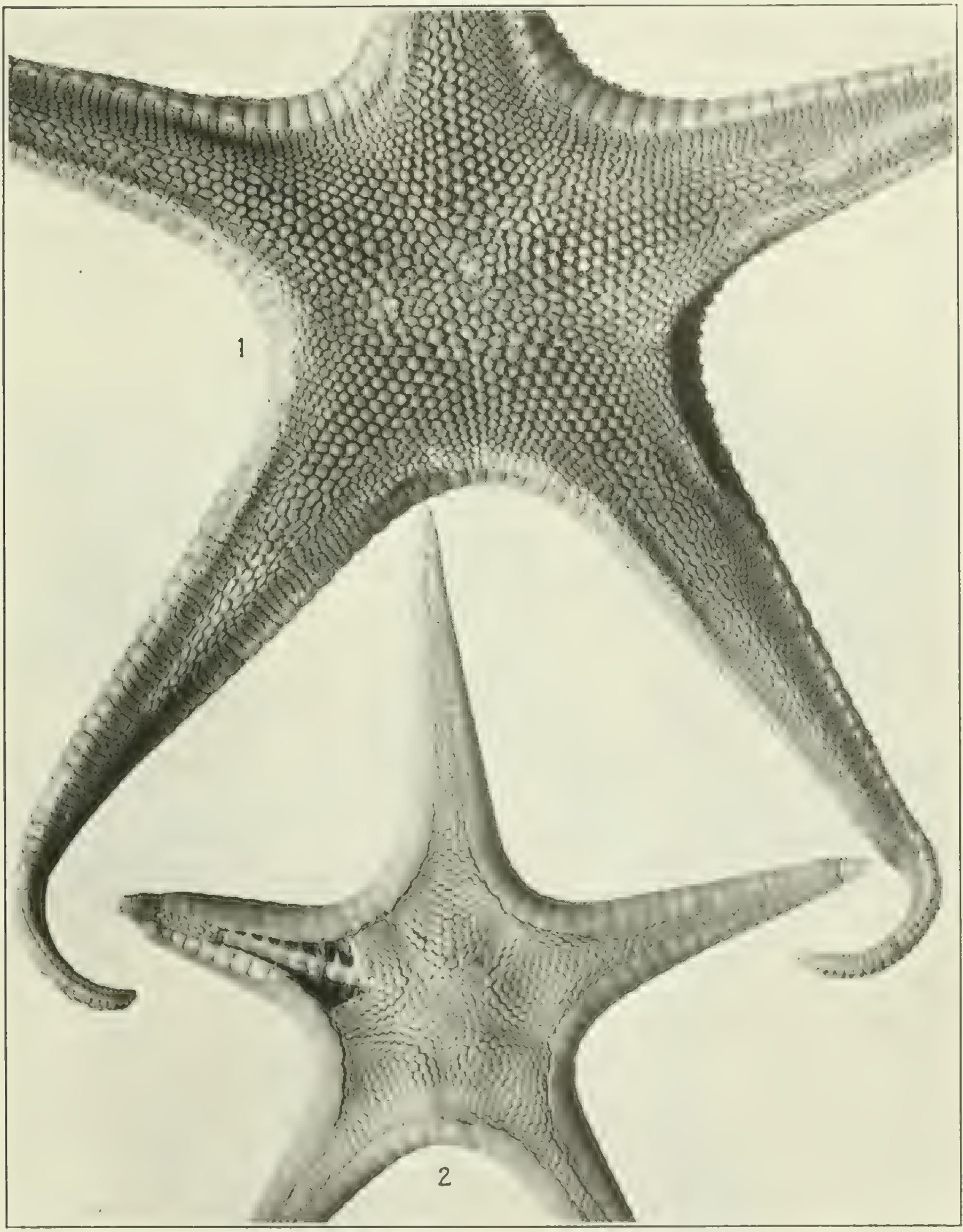
PLATE 58.

FIG. 1. *Radiaster notabilis;* actinal view of type, enlarged, p. 217.
2. *Ceramaster smithi;* actinal view of type, enlarged, p. 257.

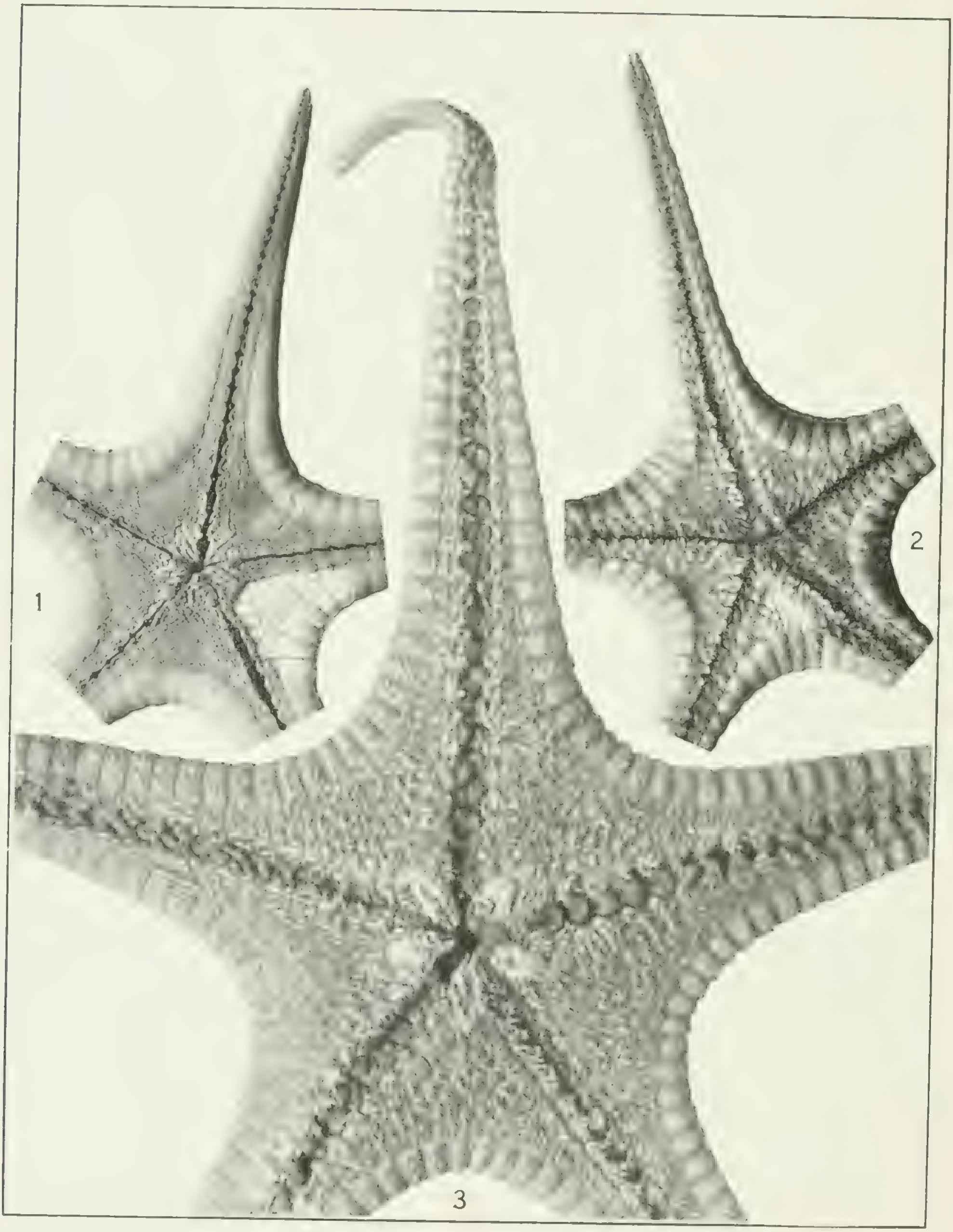
PLATE 59.

FIG. 1. *Pseudarchaster oligoporus;* abactinal aspect of type, p. 222.

2. *Aphroditaster microceramus;* abactinal aspect of type, p. 225.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



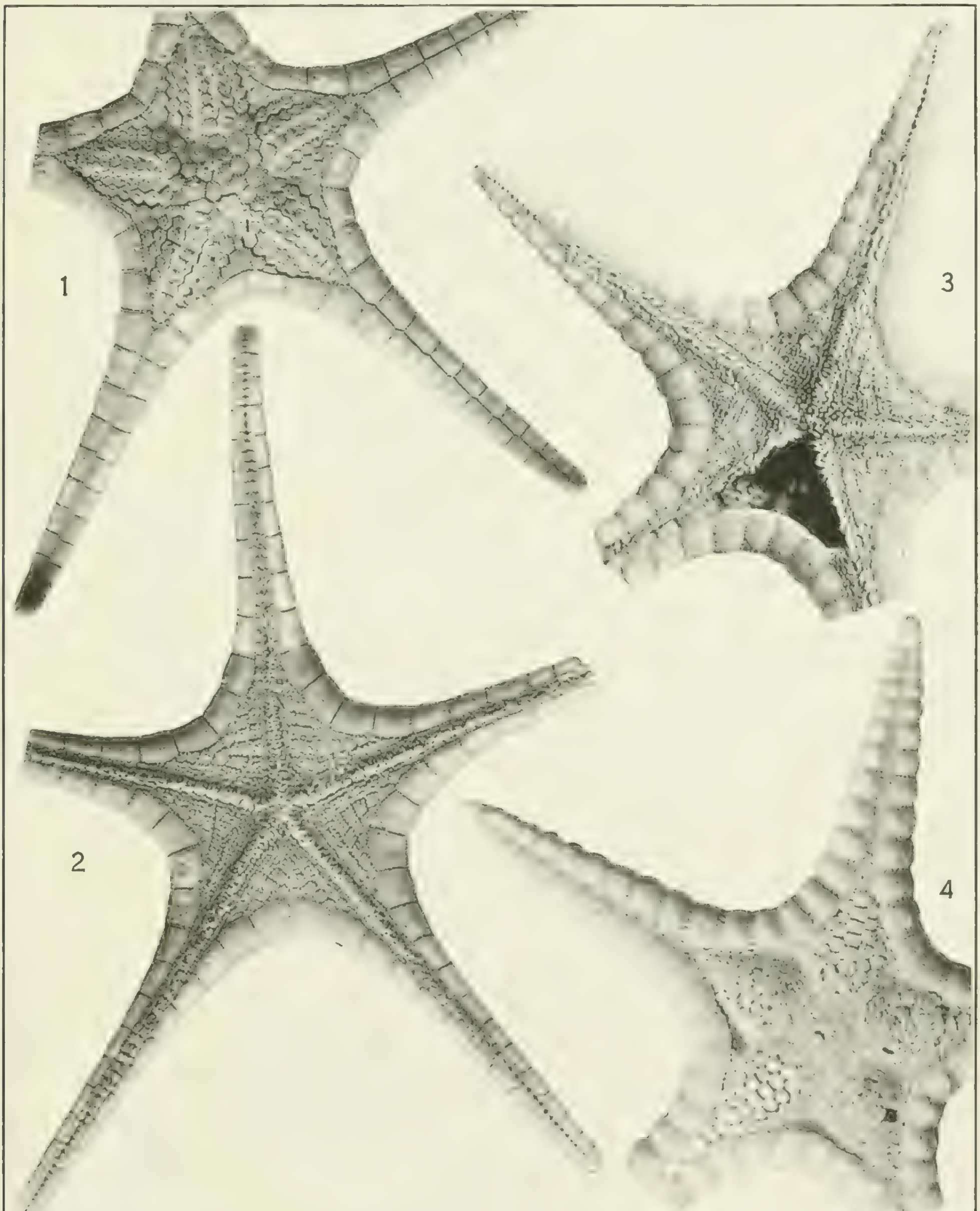
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 60.

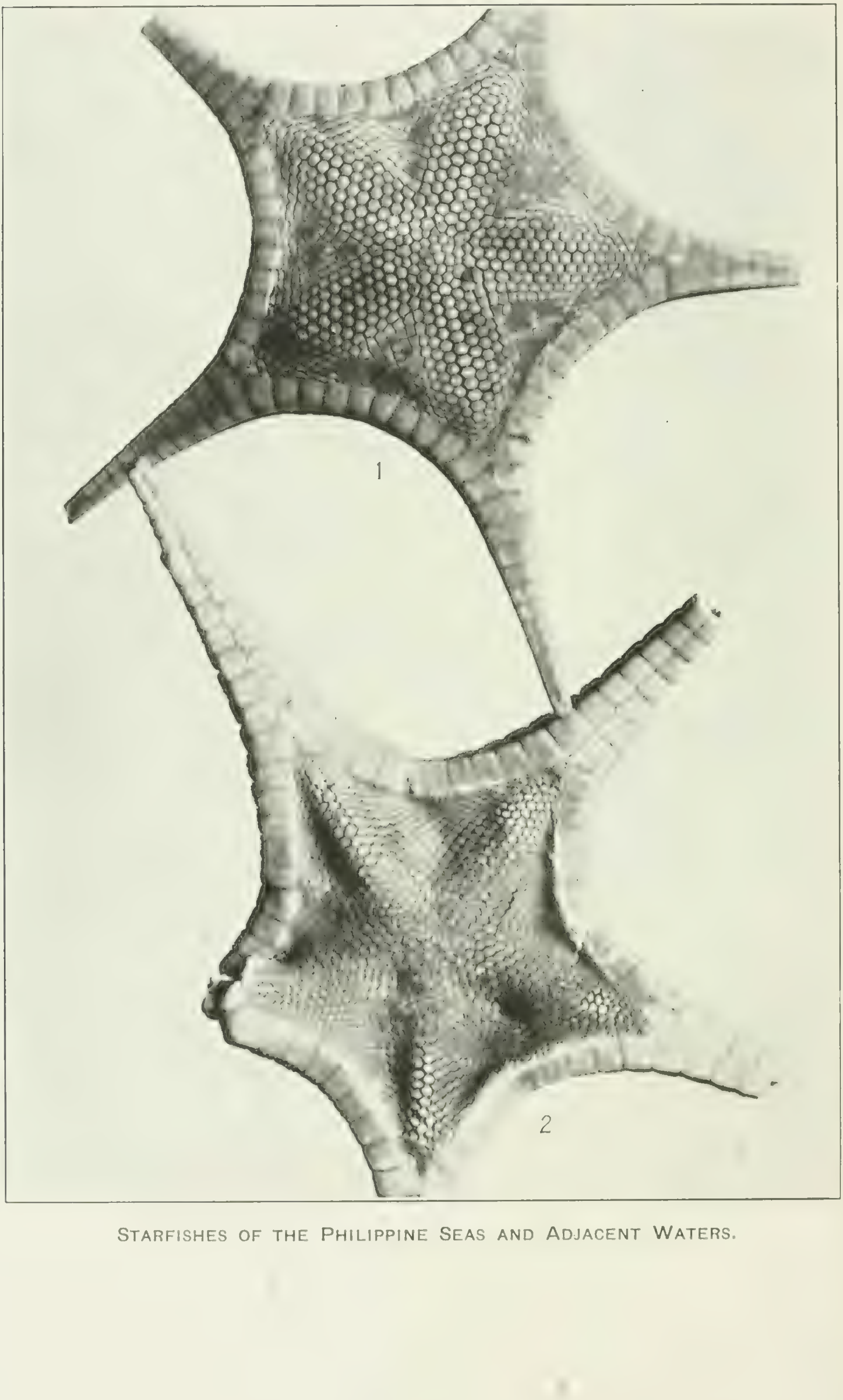
FIG. 1. *Aphroditaster microceramus;* actinal view of type, p. 225.
2. *Paragonaster stenostichus;* actinal surface of type, p. 232.
3. *Pseudarchaster oligoporus;* actinal surface of type, p. 222.

Plate 61.

Fig. 1. *Rosaster nannus*, type; abactinal aspect, enlarged, p. 244.
2. Same, type; actinal aspect, enlarged.
3. *Rosaster mamillatus;* actinal view of type, enlarged, p. 247.
4. Same; abactinal view of type, enlarged.



Starfishes of the Philippine Seas and Adjacent Waters.



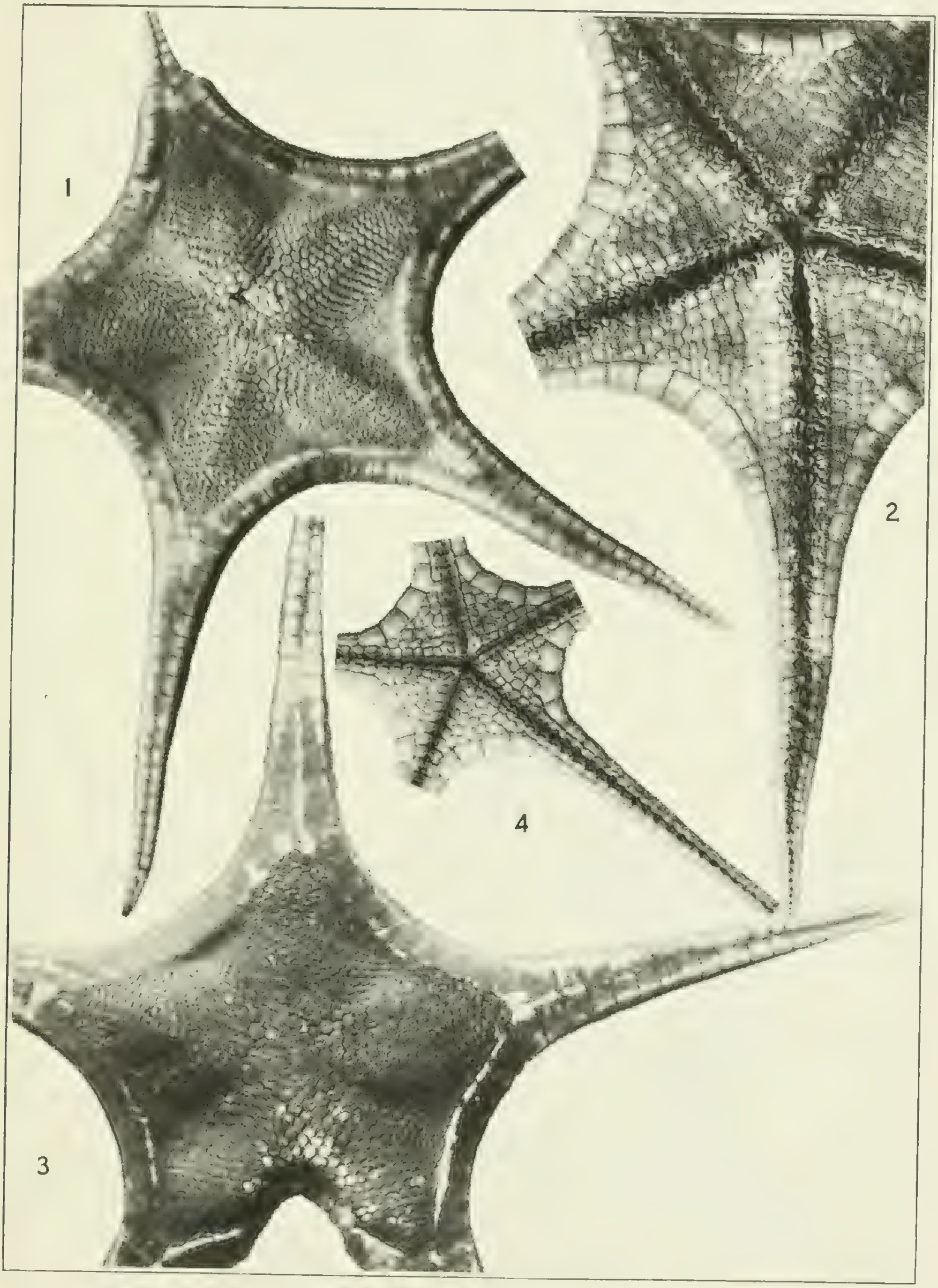
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 62.

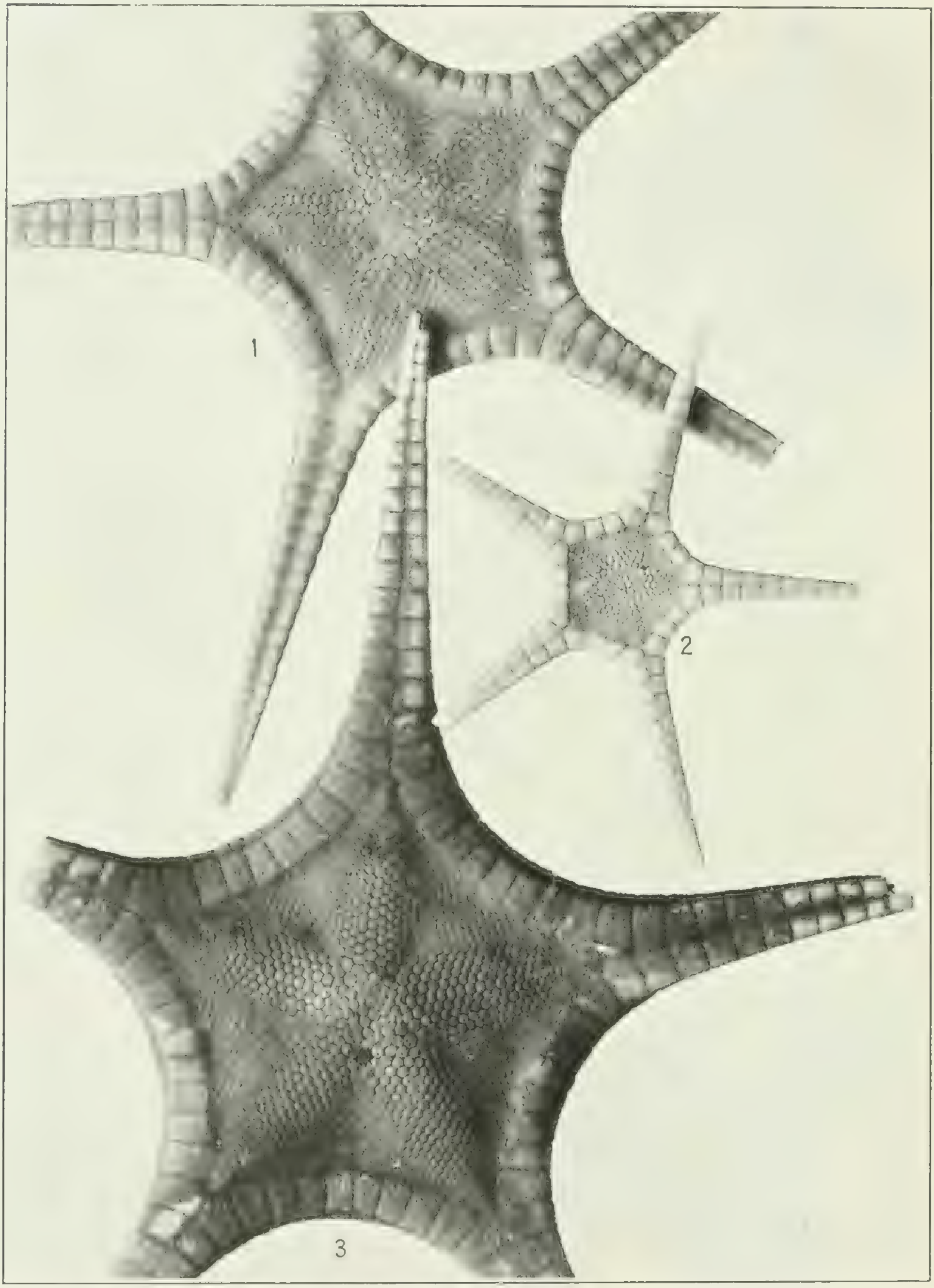
FIG. 1. *Rosaster mimicus;* abactinal surface of type, p. 250.
2. *Nymphaster dyscritus;* abactinal surface of type, p. 266.

PLATE 63.

FIG. 1. *Nymphaster mucronatus;* abactinal aspect of type, p. 269.
2. Same; actinal aspect of type.
3. *Nymphaster euryplax;* abactinal aspect of type, p. 264.
4. *Nymphaster atopus;* actinal surface of type, p. 285.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



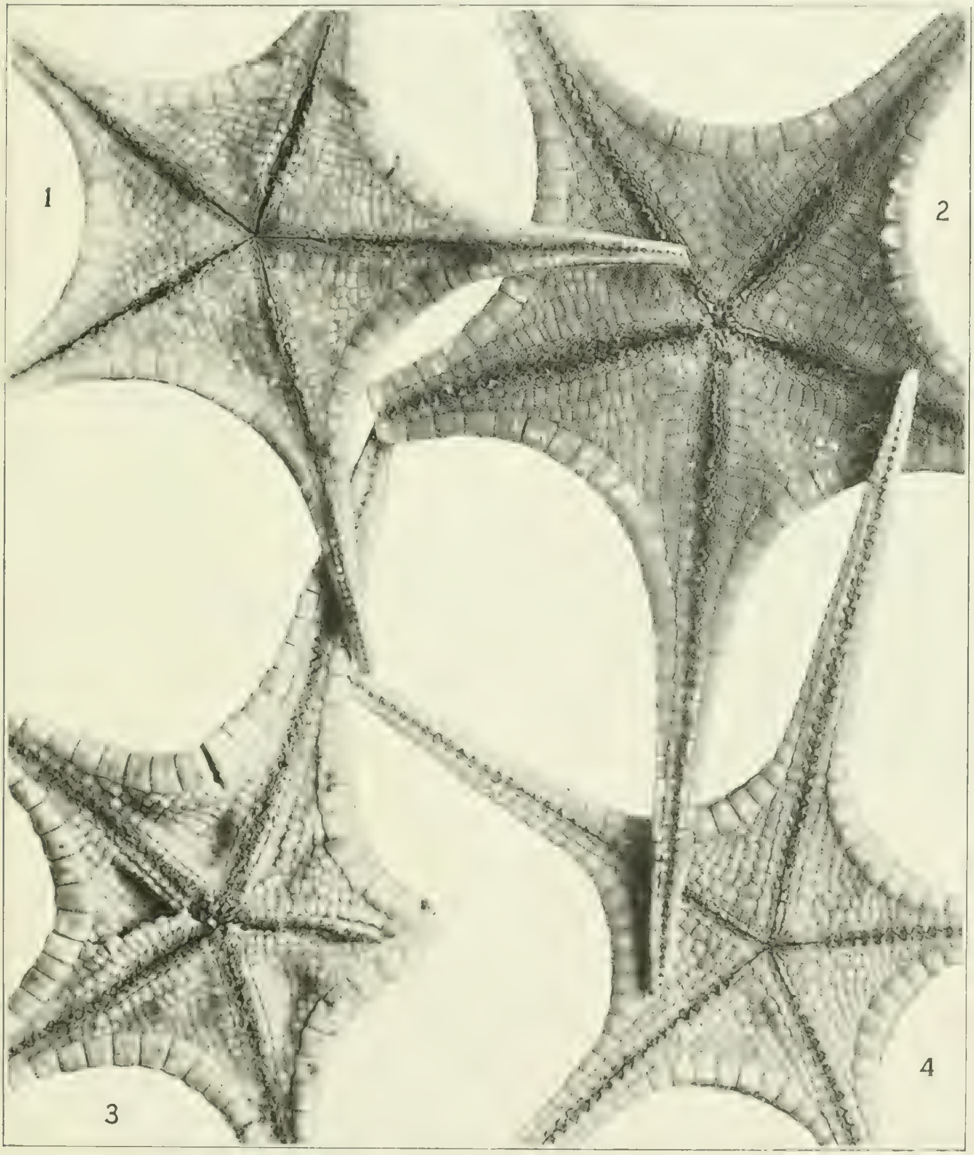
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 64.

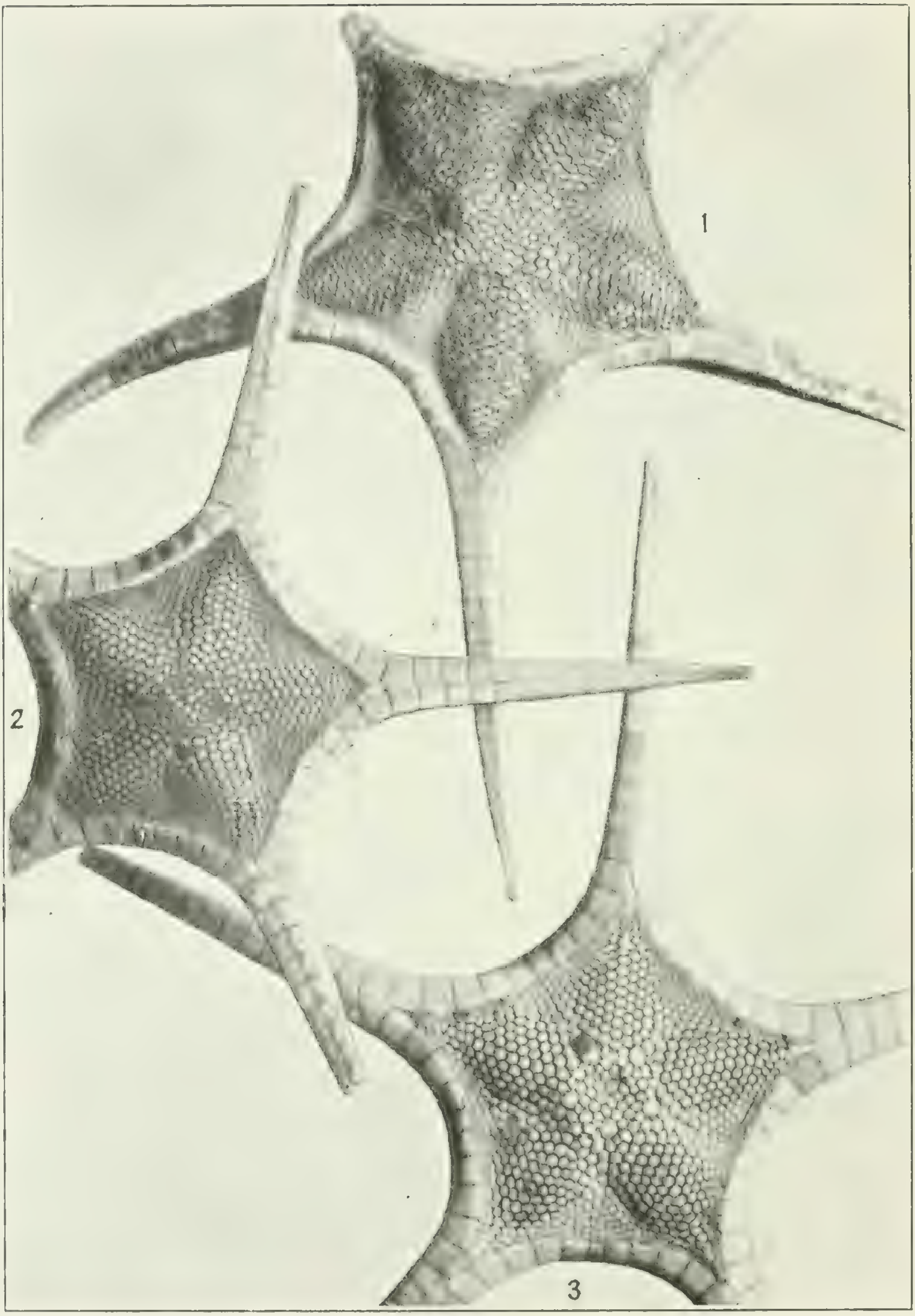
Fig. 1. *Nymphaster arthrocnemis*, type; abactinal aspect, p. 277.
2. *Nymphaster atopus*, type; abactinal view, p. 285.
3. *Nymphaster moluccanus*, type; abactinal view, p. 274.

PLATE 65.

FIG. 1. *Rosaster mimicus*, type; actinal view, p. 250.
2. *Nymphaster moluccanus*, type; actinal view, p. 274.
3. *Nymphaster dyscritus*, type; actinal view, p. 266.
4. *Nymphaster arthrocnemis*, type; actinal view, p. 277.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



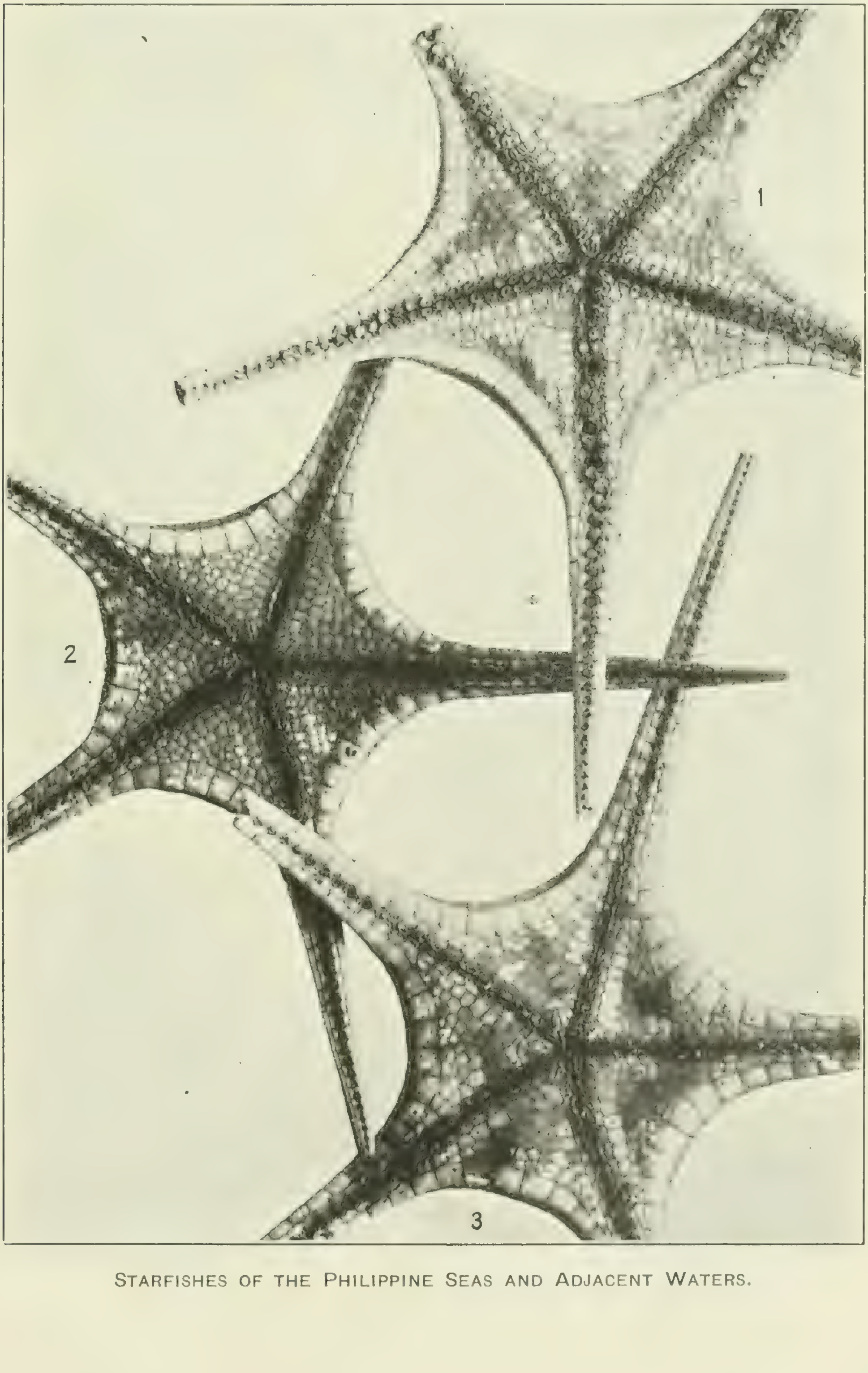
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 66.

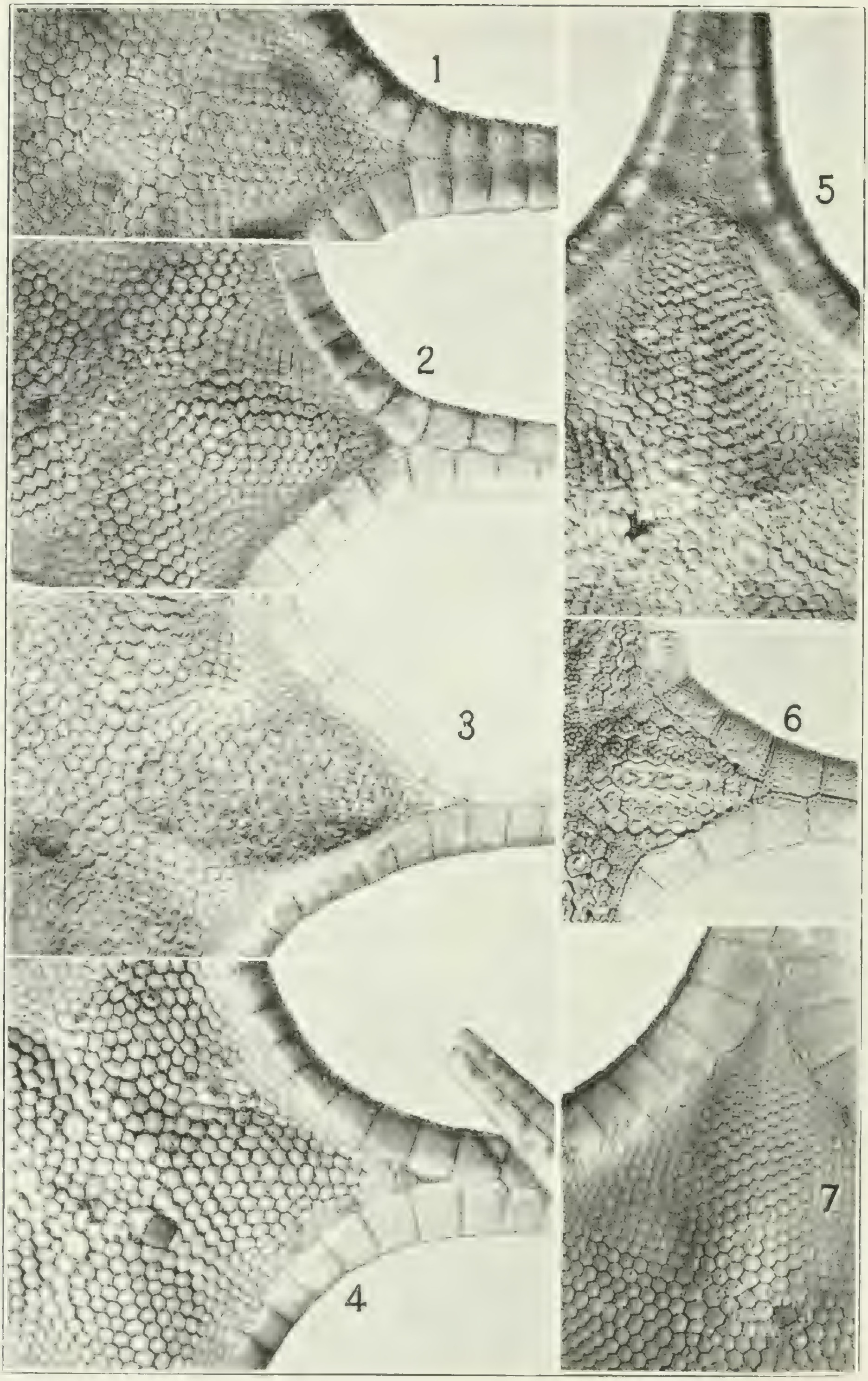
Fig. 1. *Nymphaster leptodomus*, type; abactinal view, p. 272.
2. *Nymphaster meseres*, type; abactinal view, p. 280.
3. *Nymphaster habrotatus*, type; abactinal view, p. 282.

Plate 67.

Fig. 1. *Nymphaster leptodomus*, type; actinal view, p. 272.
2. *Nymphaster meseres*, type; actinal view, p. 280.
3. *Nymphaster habrotatus*, type; actinal view, p. 282.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 68.

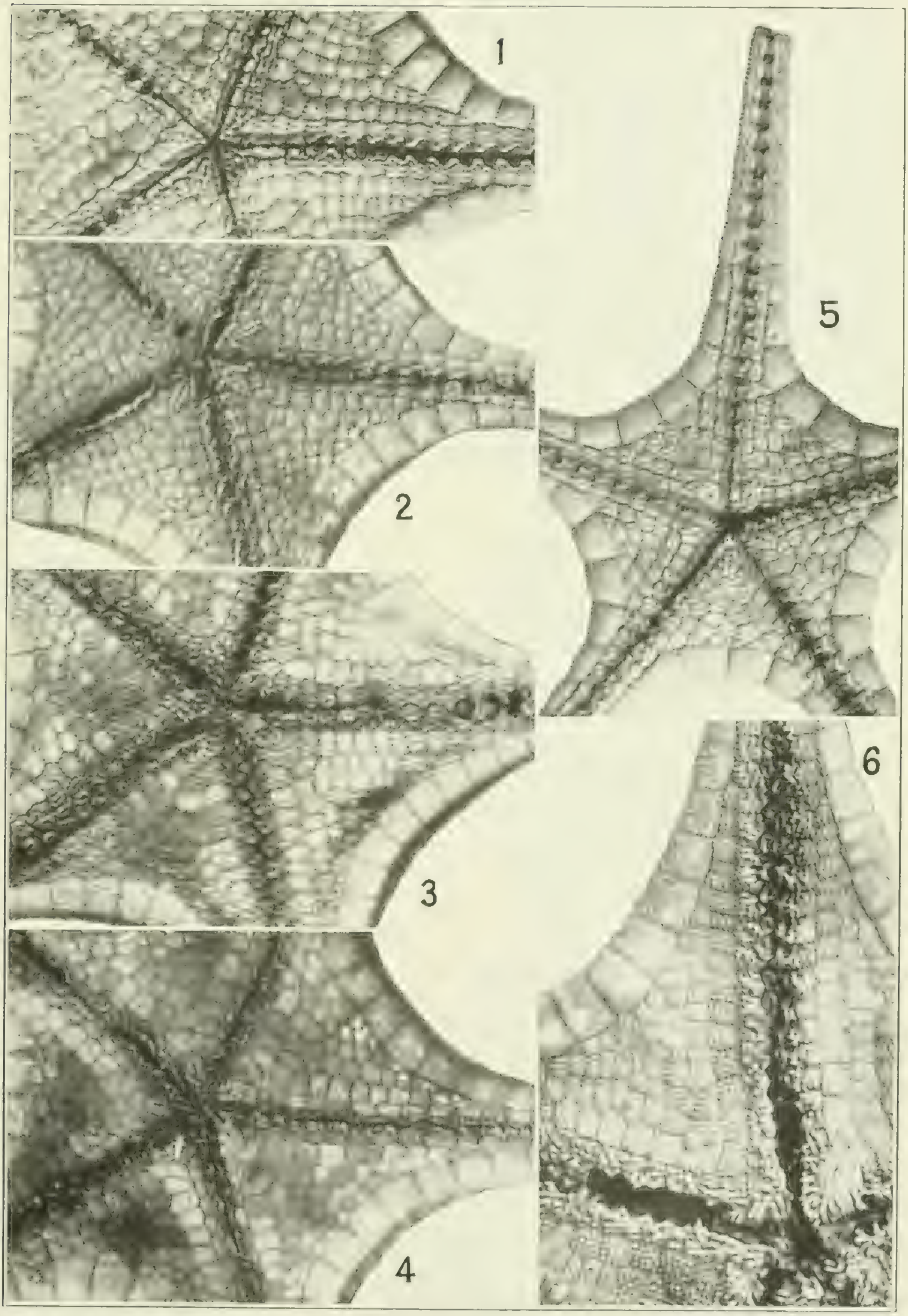
Enlarged details of abactinal surface.

FIG. 1. *Nymphaster arthrocnemis*, p. 277.
2. *Nymphaster meseres*, p. 280.
3. *Nymphaster leptodomus*, p. 272.
4. *Nymphaster habrotatus*, p. 282.
5. *Nymphaster mucronatus*, p. 269.
6. *Rosaster nannus*, p. 244.
7. *Nymphaster moluccanus*, p. 274.

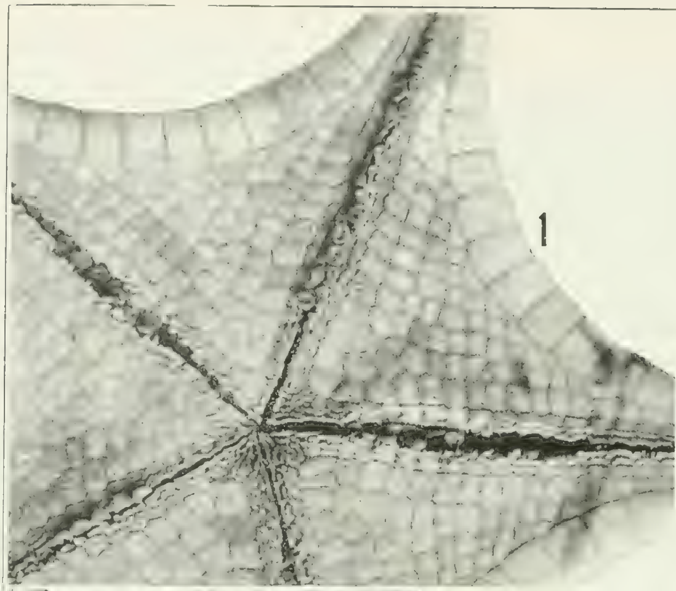
PLATE 69.

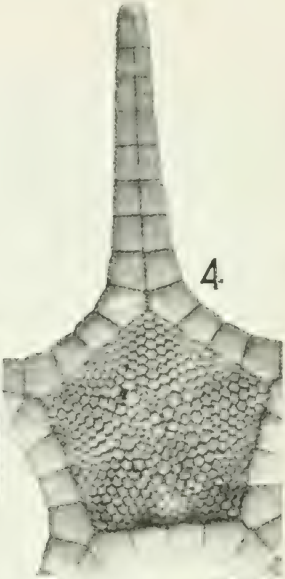
Enlarged details of actinal surface.

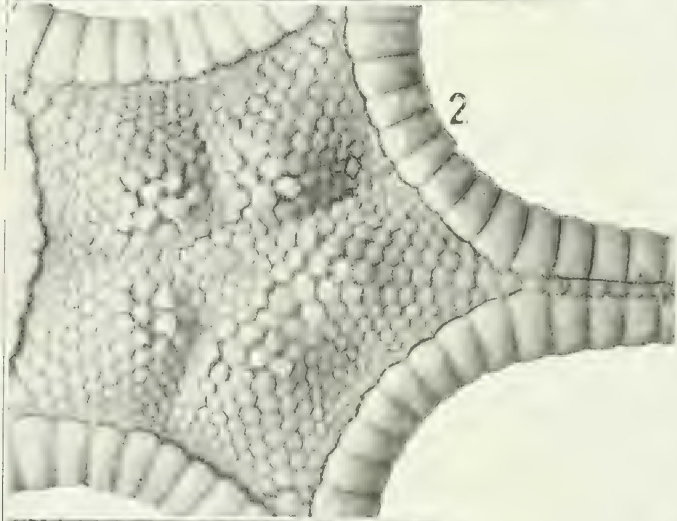
FIG. 1. *Nymphaster arthrocnemis*, p. 277.
2. *Nymphaster meseres*, p. 280.
3. *Nymphaster leptodomus*, p. 272.
4. *Nymphaster habrotatus*, p. 282.
5. *Nymphaster atopus*, p. 285.
6. *Nymphaster mucronatus*, p. 269.

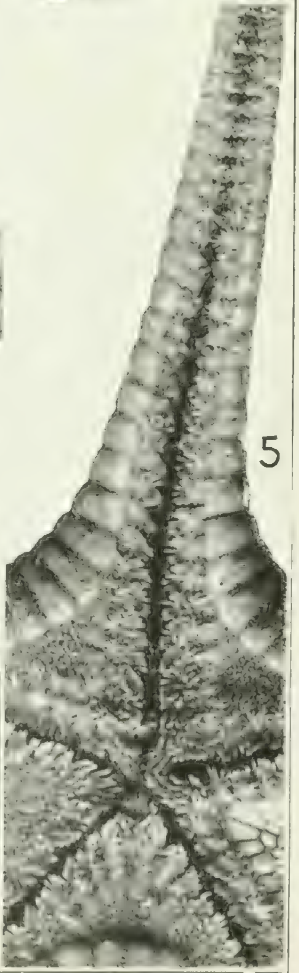


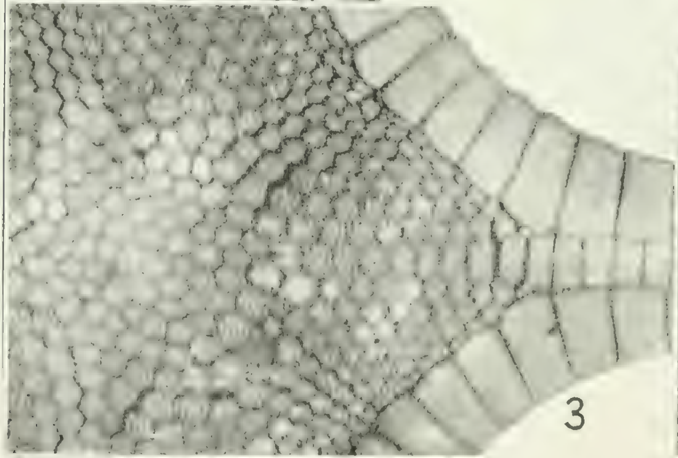
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.


1


4


2


5


3

STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

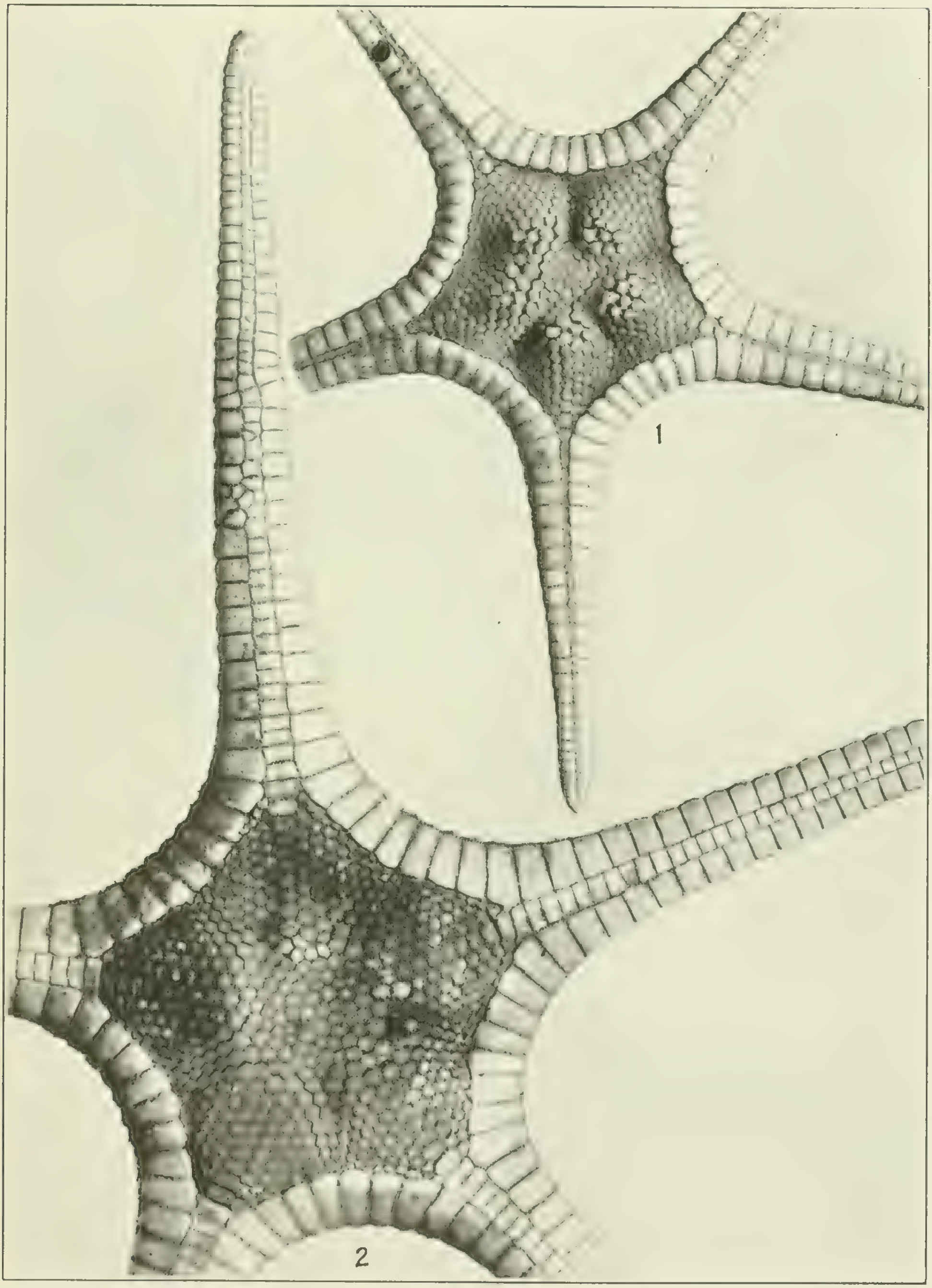
PLATE 70.

Enlarged details of abactinal and actinal surfaces.

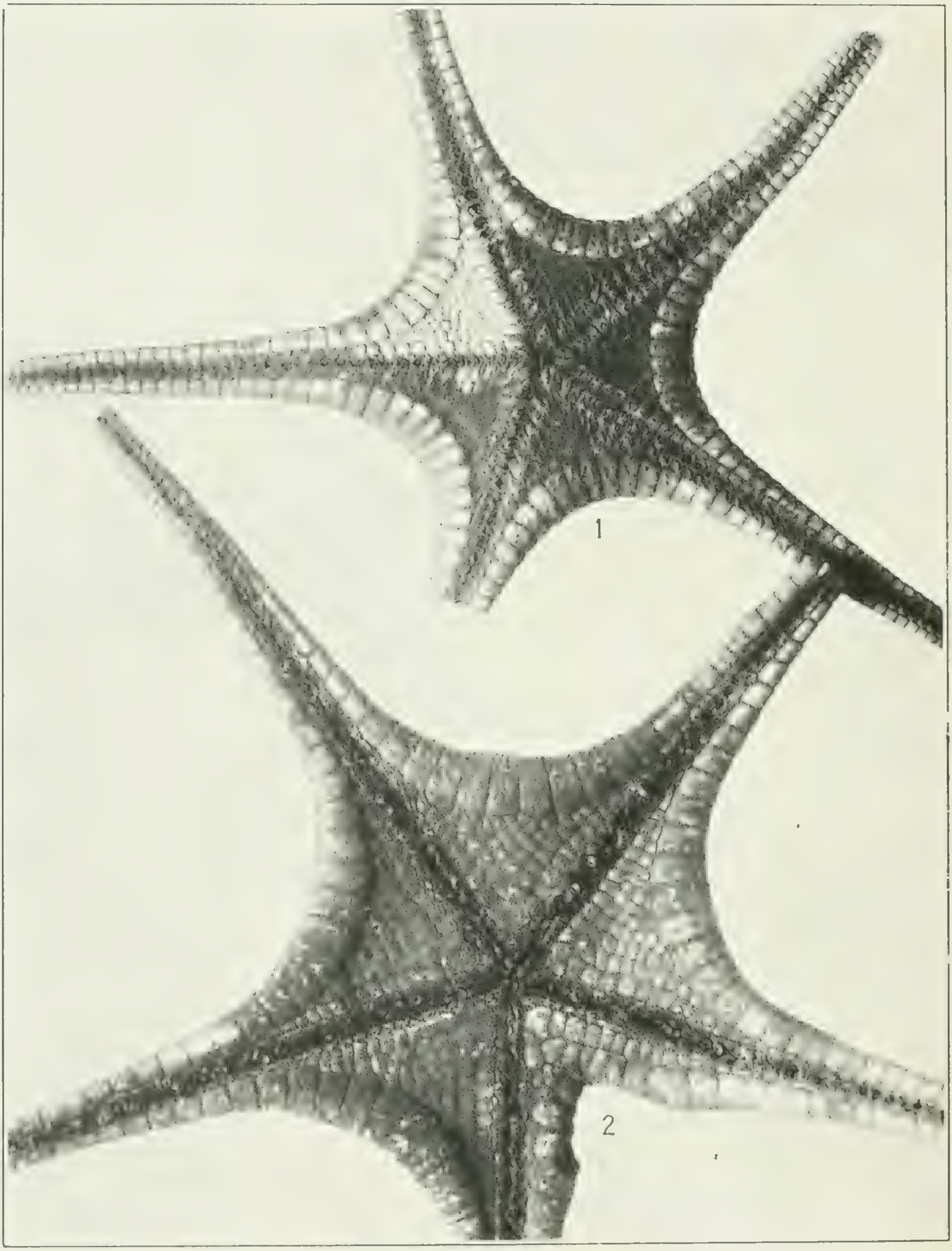
FIG. 1. *Rosaster mimicus*, actinal, p. 250.
2. *Paragonaster stenostichus*, abactinal, p. 232.
3. *Paragonaster ctenipes hypacanthus*, abactinal, p. 228.
4. *Nymphaster atopus*, abactinal, p. 285.
5. *Aphroditaster microceramus*, actinal, p. 225.

PLATE 71.

FIG. 1. *Paragonaster stenostichus*, type; abactinal aspect of type, p. 232.
2. *Paragonaster ctenipes hypacanthus*, type; abactinal view of type, p. 228.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



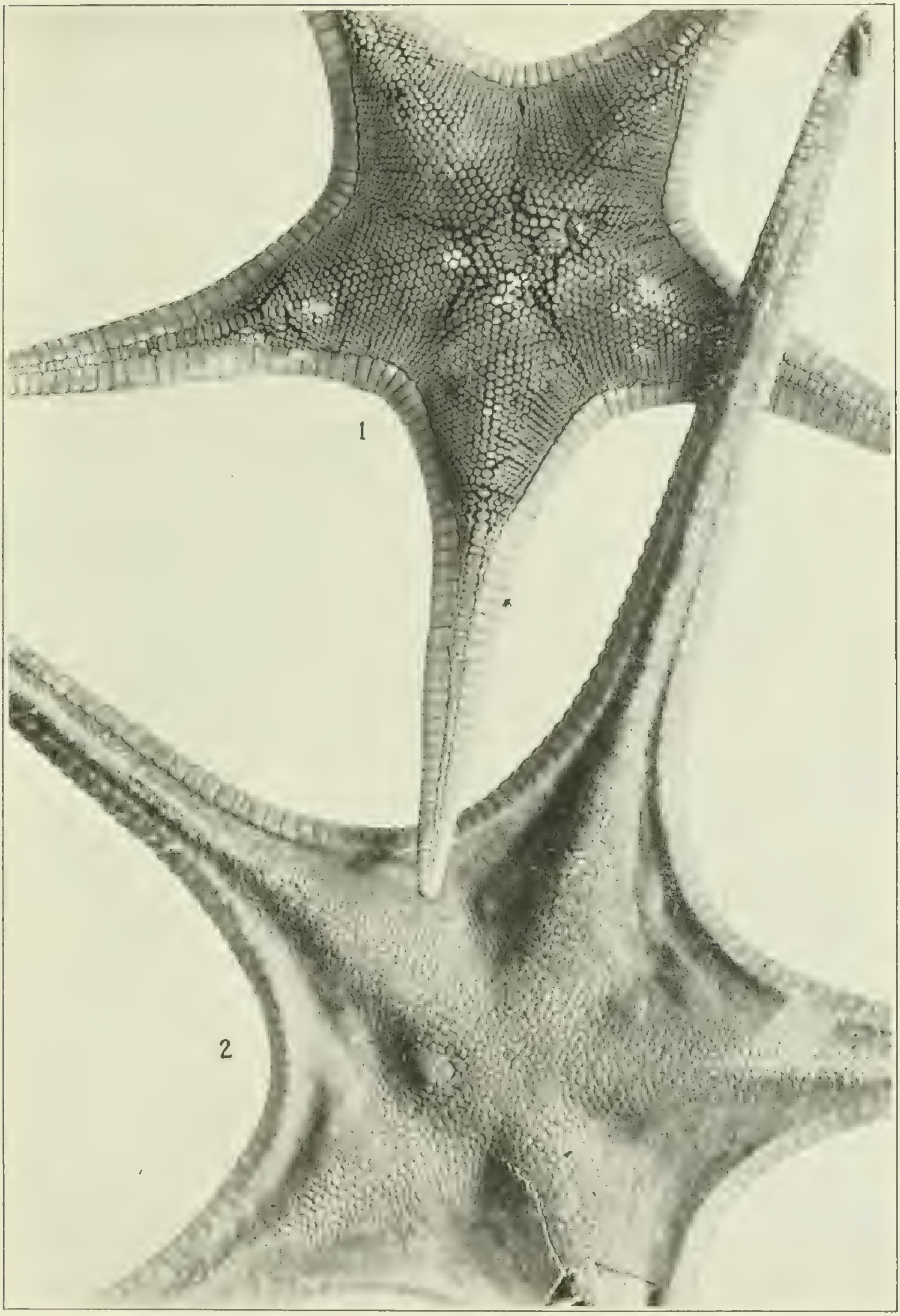
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 72.

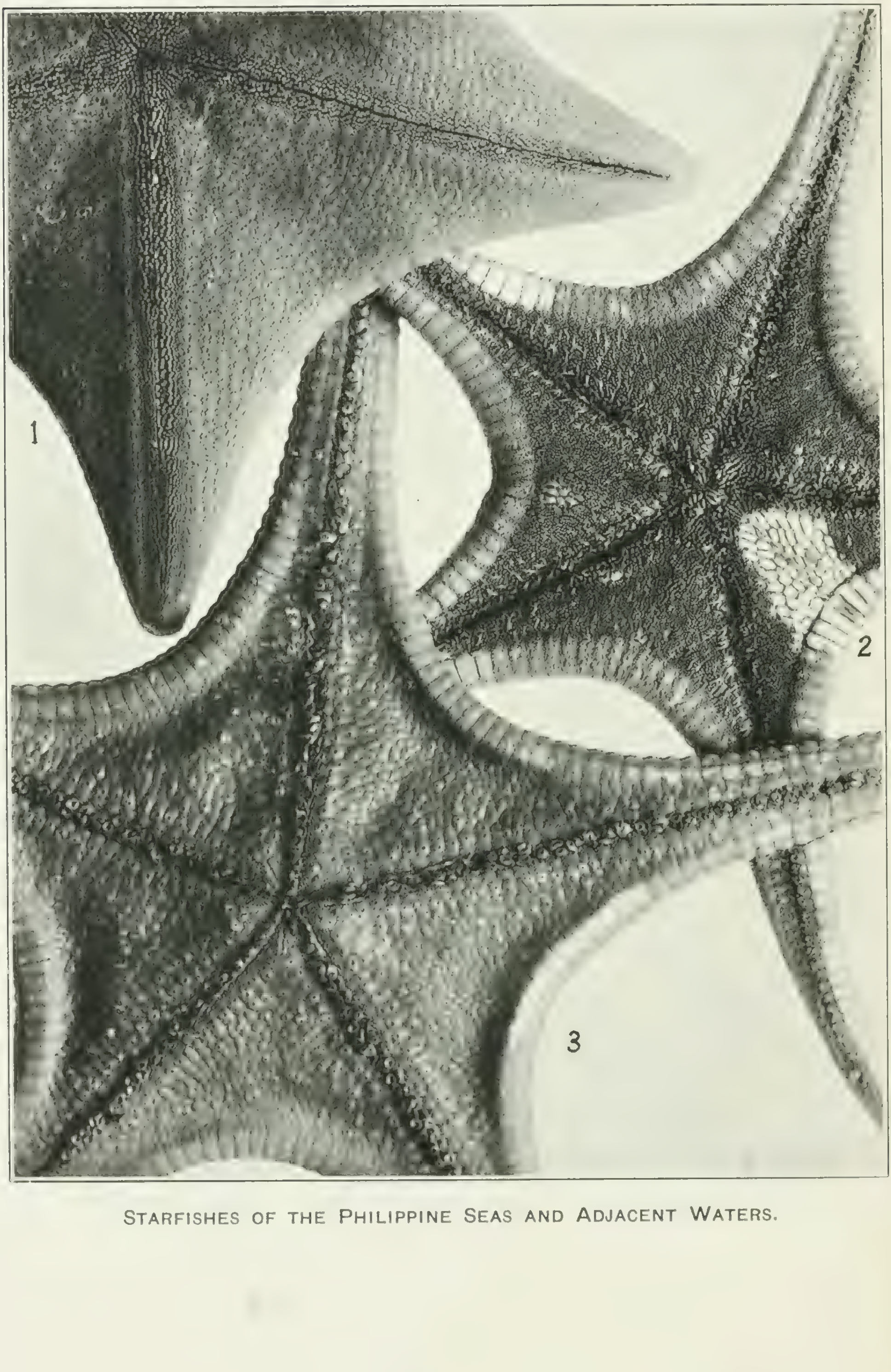
Fig. 1. *Paragonaster ctenipes hypacanthus*, type; actinal surface, p. 228.
2. *Nymphaster euryplax*, type; actinal aspect, p. 264.

PLATE 73.

FIG. 1. *Perissogonaster insignis;* abactinal view of type, reduced, p. 236.
2. *Atelorias anacanthus;* abactinal aspect of type, reduced, p. 343.
620



Starfishes of the Philippine Seas and Adjacent Waters.



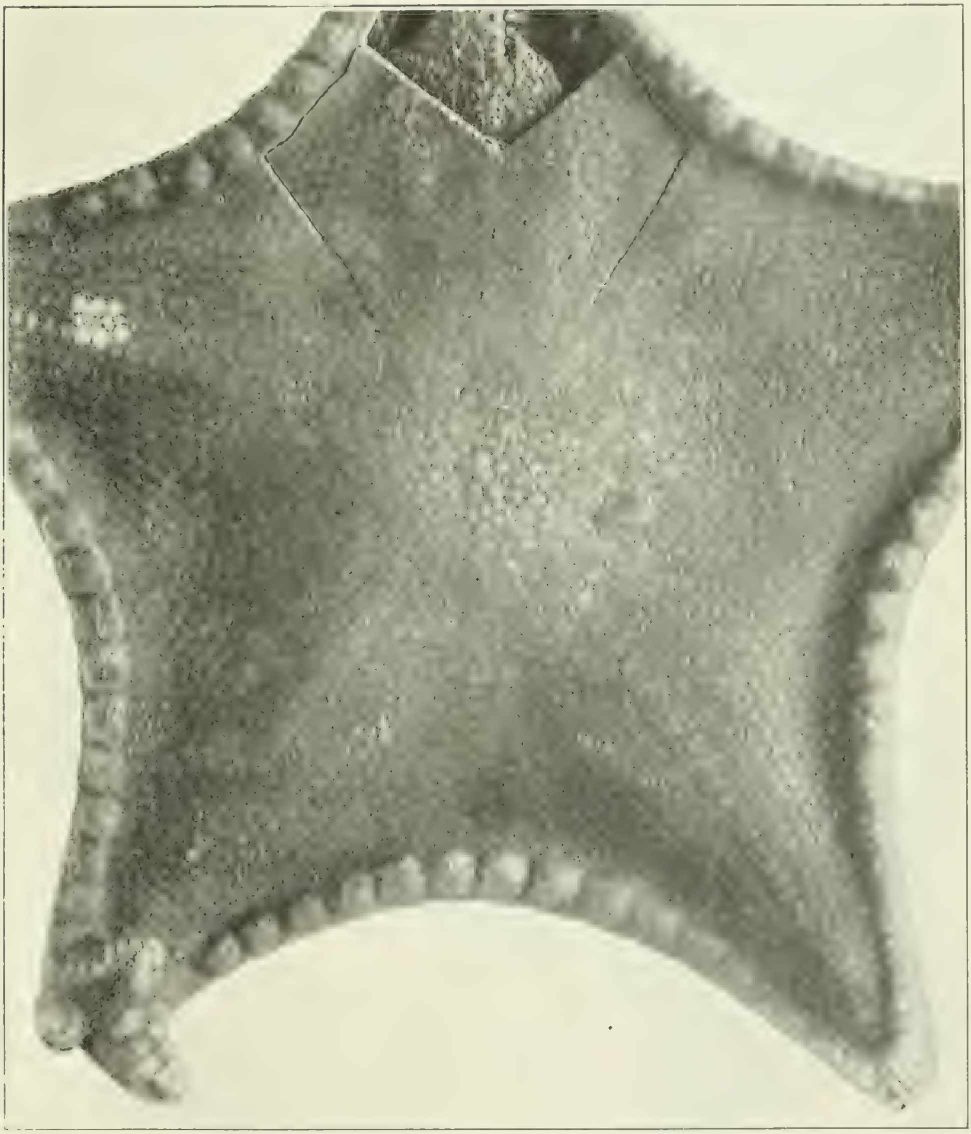
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 74.

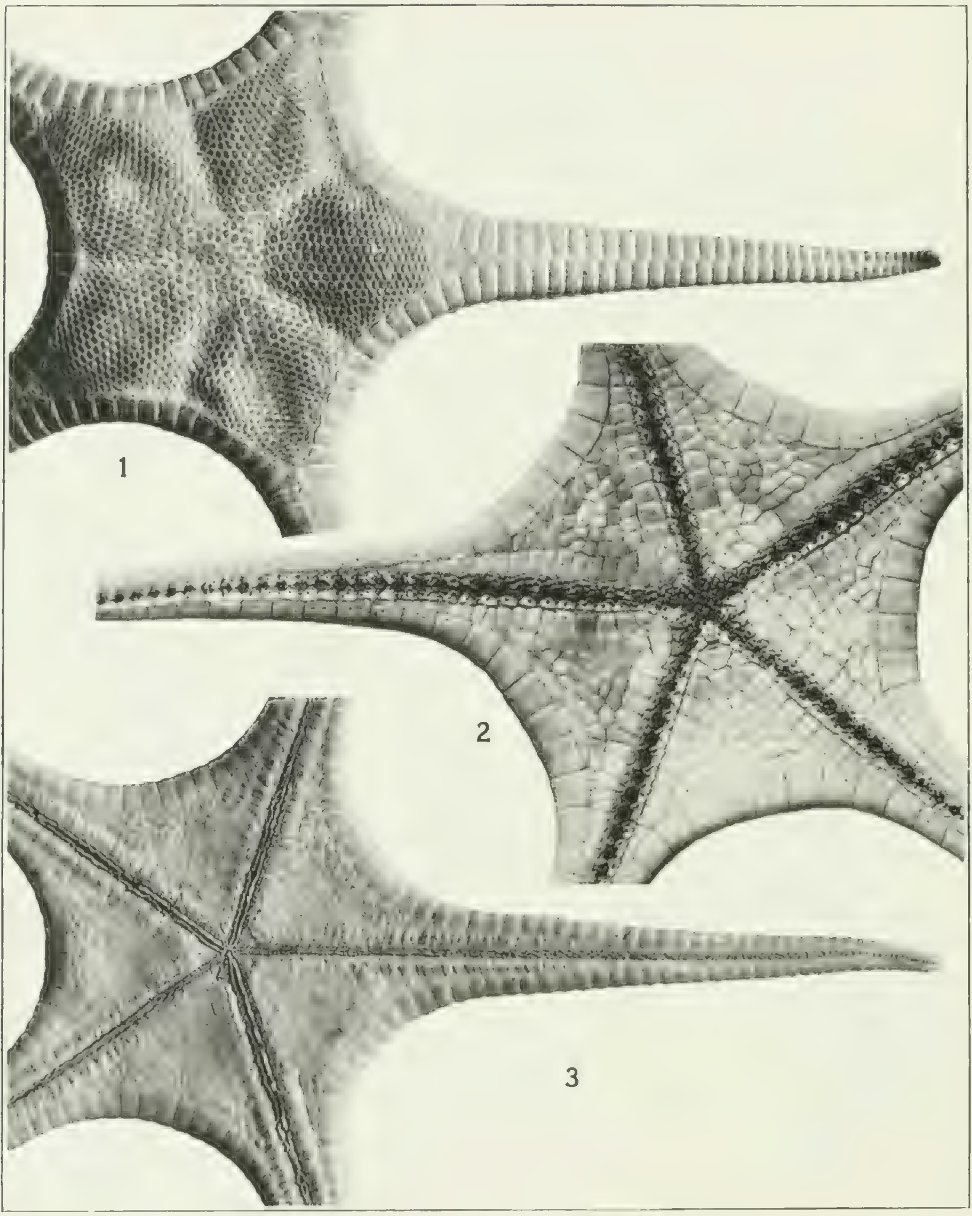
Fig. 1. *Peltaster cycloplax;* actinal surface of type, reduced, p. 290.
2. *Perissogonaster insignis;* actinal surface of type, reduced, p. 236.
3. *Atelorias anacanthus;* actinal surface of type, reduced, p. 343.

PLATE 75.

Peltaster cycloplax, type; abactinal view, p. 290.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 76.

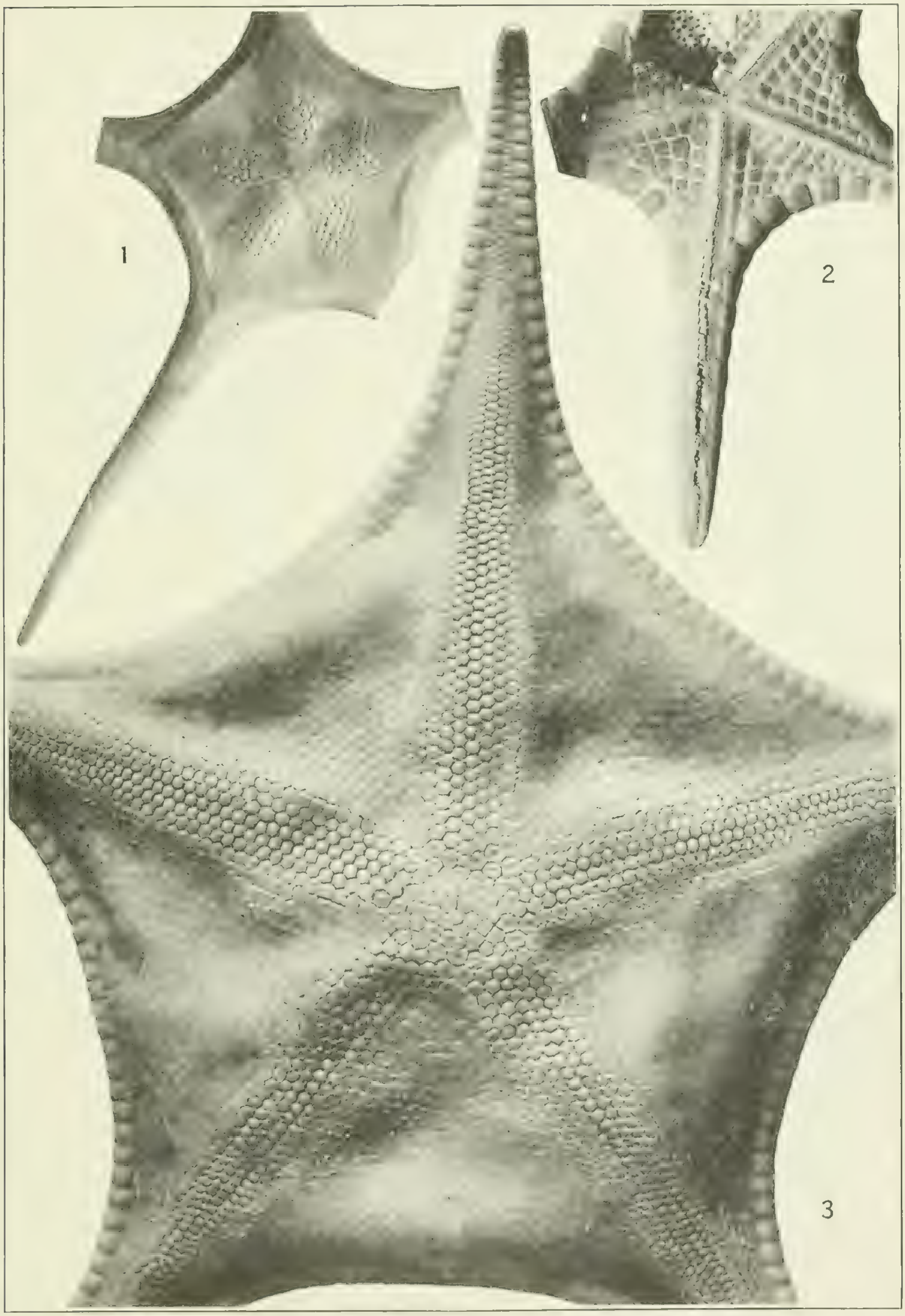
Fig. 1. *Lithosoma actinometra;* abactinal surface of type, reduced, p. 298.

2. *Lithosoma penichra;* actinal surface of type, enlarged, p. 301.

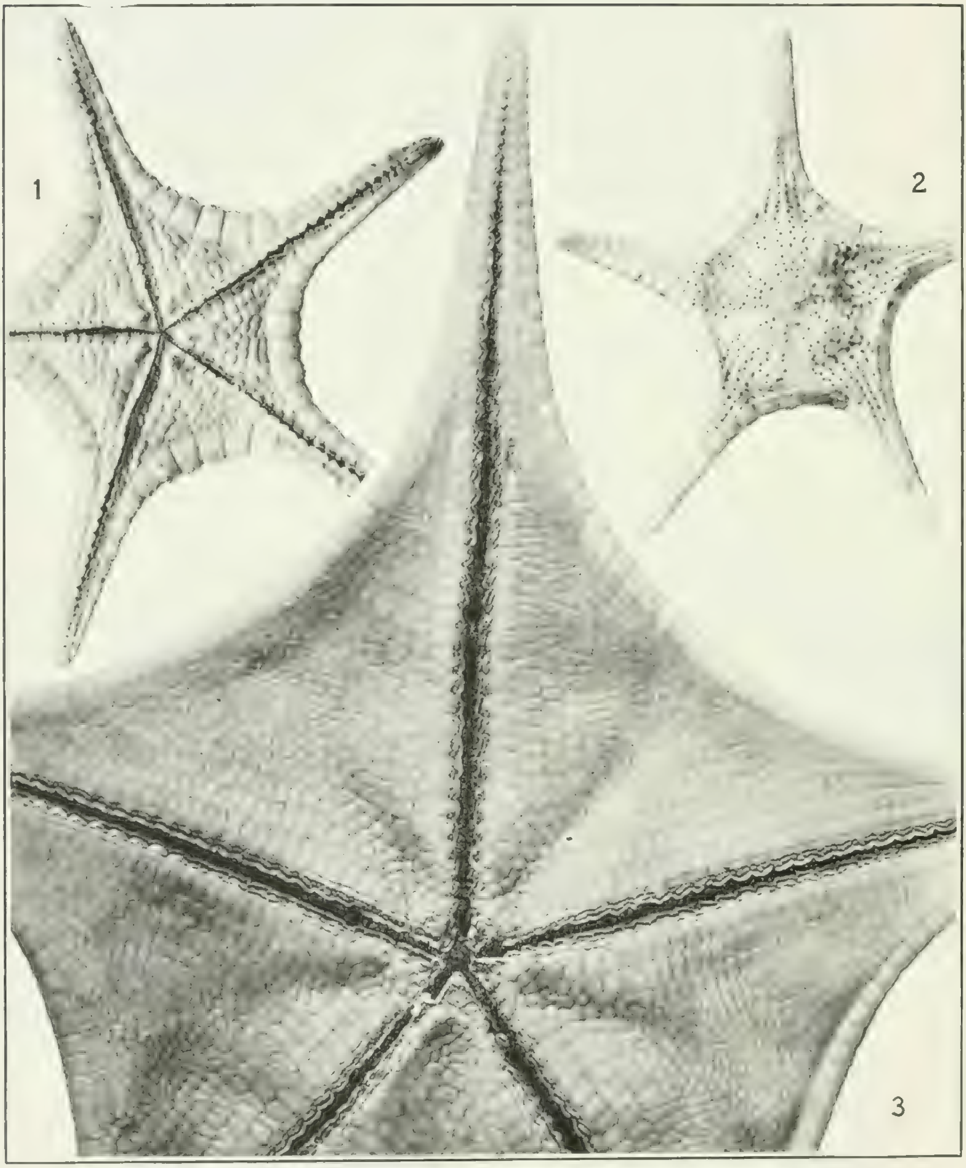
3. *Lithosoma actinometra;* actinal surface type, reduced, p. 298.

PLATE 77.

Fig. 1. *Lithosoma penichra;* abactinal surface of type, p. 301.
2. *Iconaster longimanus;* actinal surface, p. 303.
3. *Pontioceramus grandis;* abactinal surface of type, p. 294.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 78.

FIG. 1. *Anthenoides cristatus;* actinal surface of young specimen, enlarged, p. 329.

2. Same; abactinal surface of young specimen, enlarged.

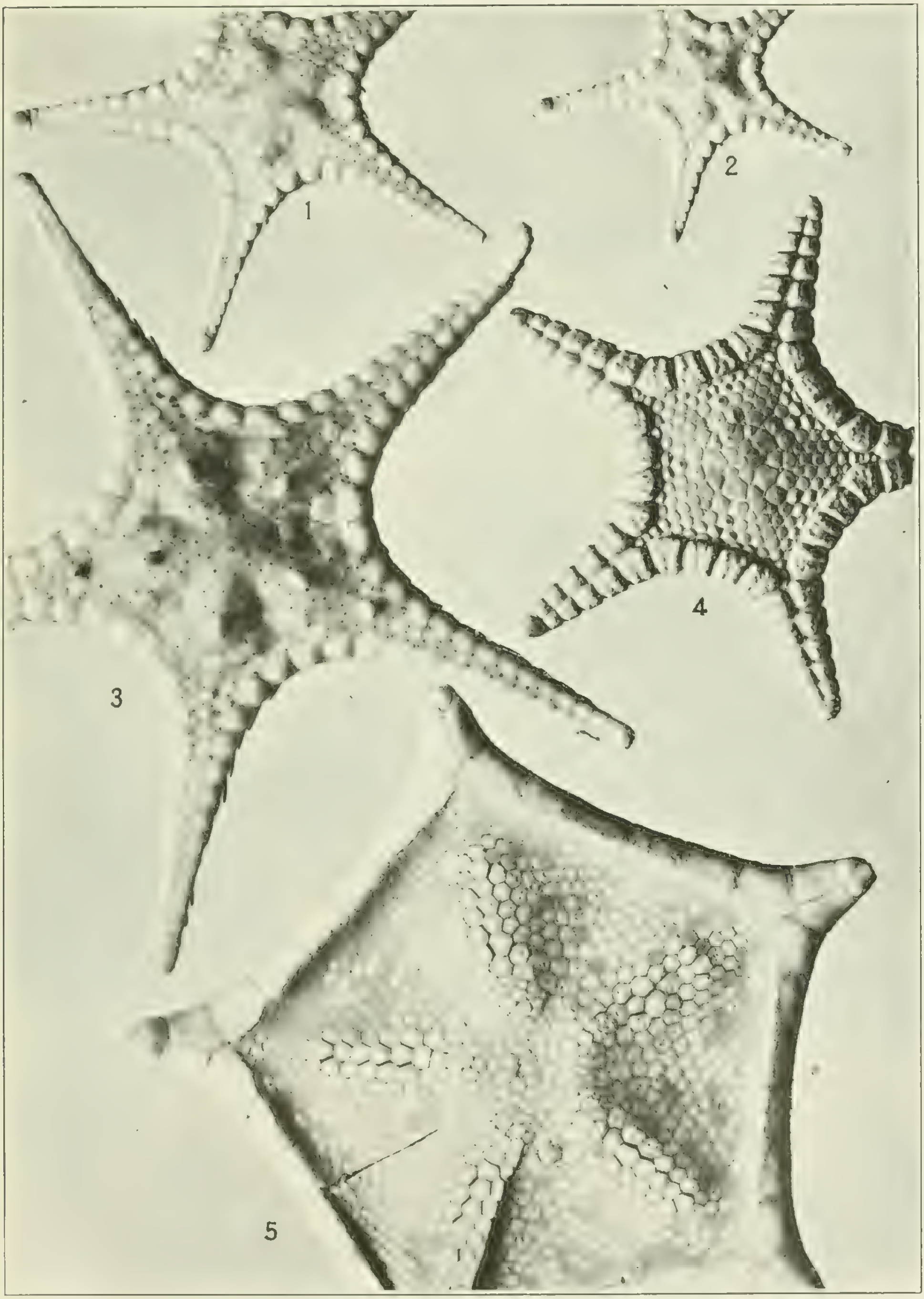
3. *Pontioceramus grandis;* actinal aspect of type, p. 294.

PLATE 79.

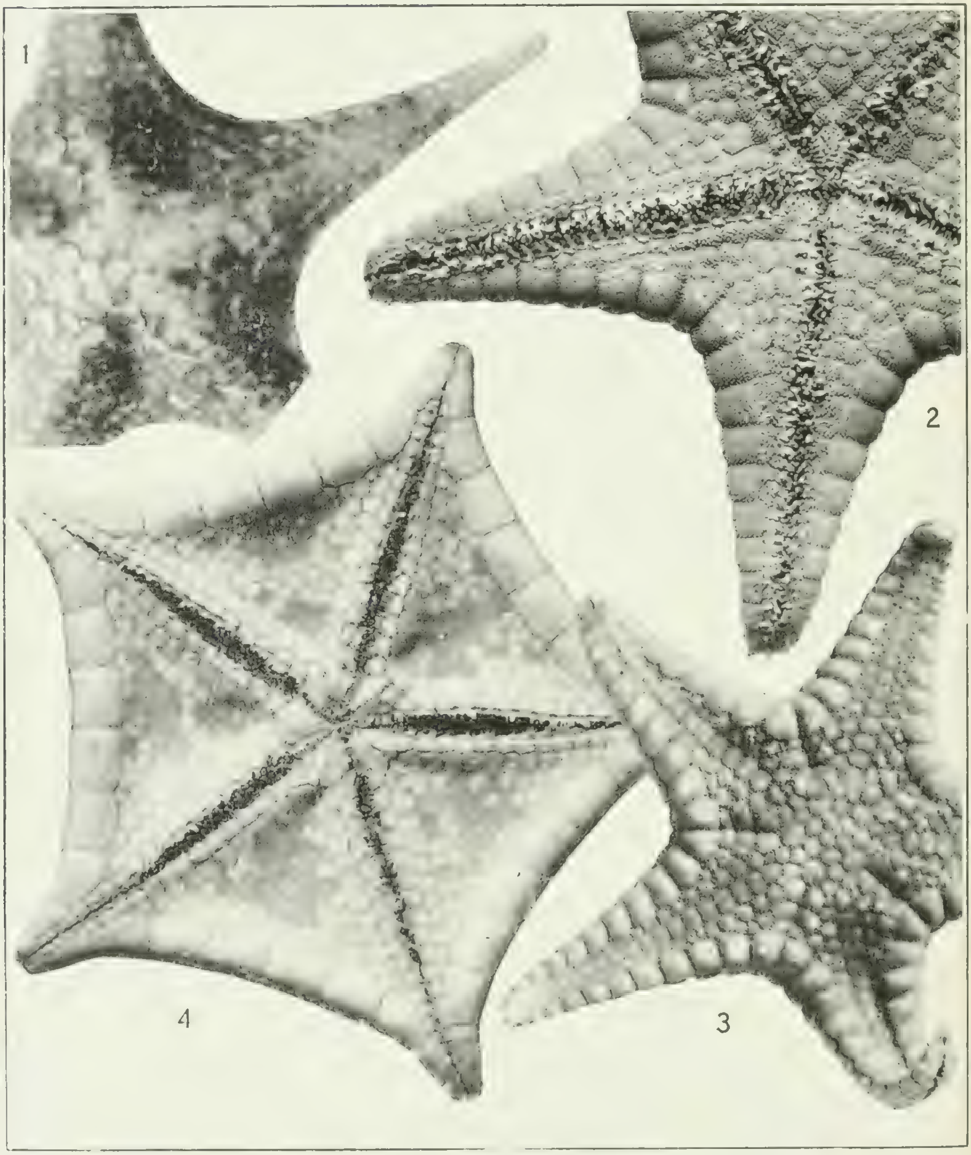
FIGS. 1–3. *Stellaster incei;* 3 specimens from station 5358, enlarged, to show variations, p. 326.

4. *Iconaster perierctus;* abactinal surface of type, enlarged, p. 306.

5. *Sphaeriodiscus scotocryptus;* abactinal surface of type, enlarged, p. 287.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 80.

Fig. 1. *Stellaster incei;* specimen from station 5483, slightly enlarged, showing absence of abactinal spines, p. 326.

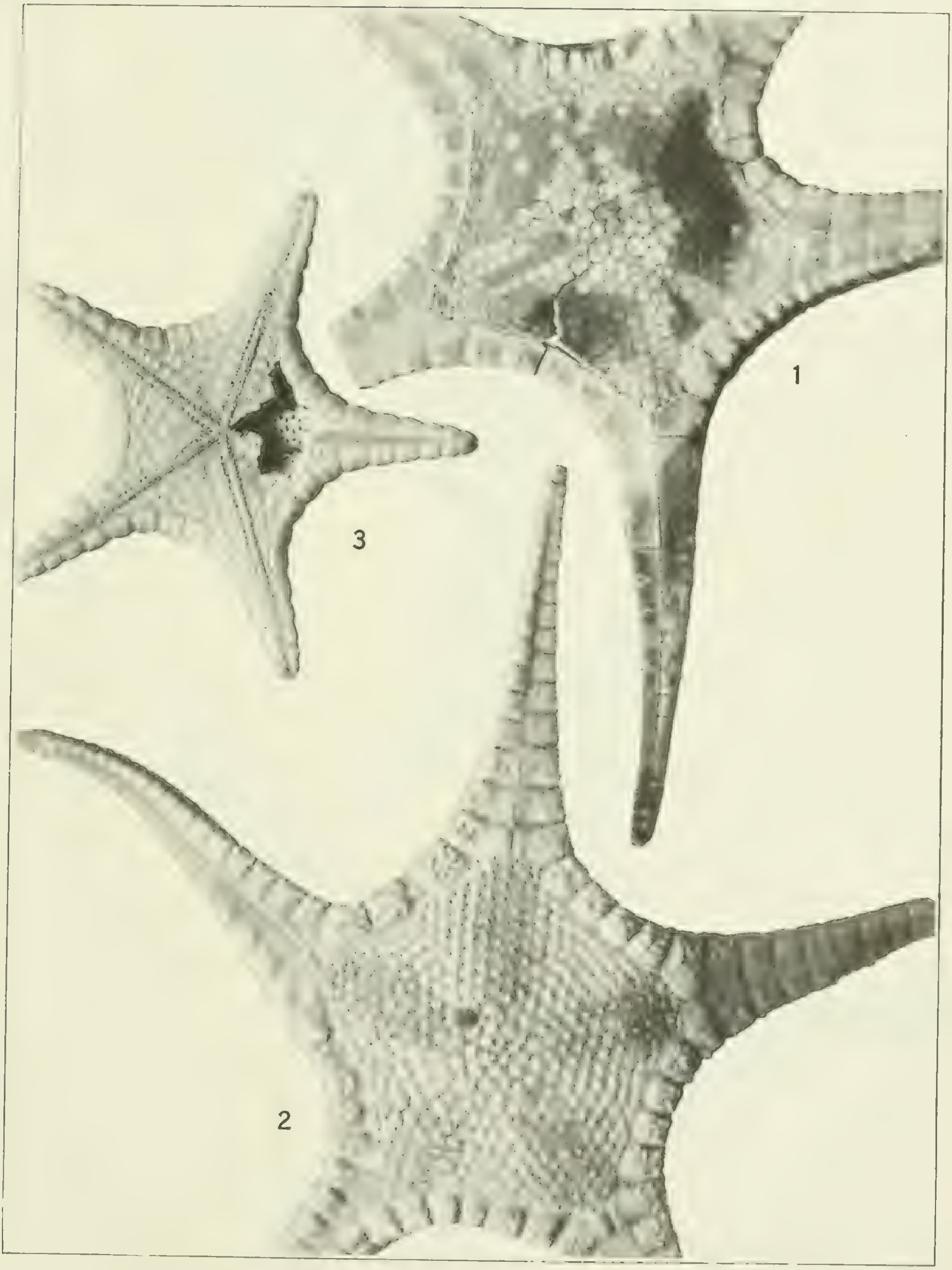
2. *Goniodiscaster forficulatus;* actinal surface, enlarged, p. 324.

3. Same; abactinal surface.

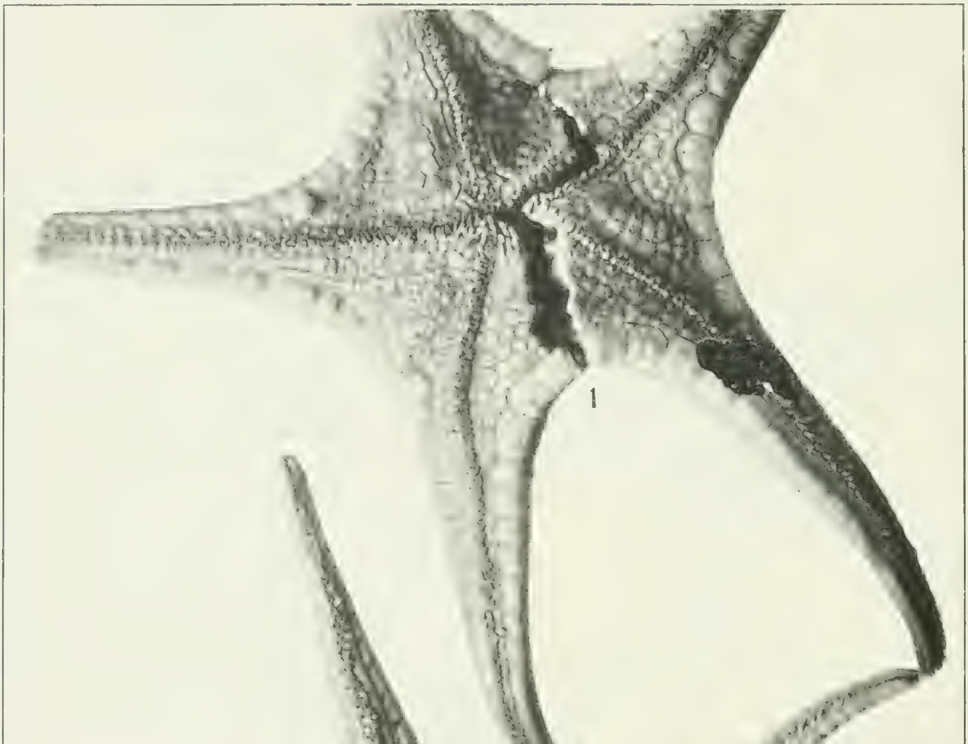
4. *Sphaeriodiscus scotocryptus;* actinal surface of type, enlarged, p. 287.

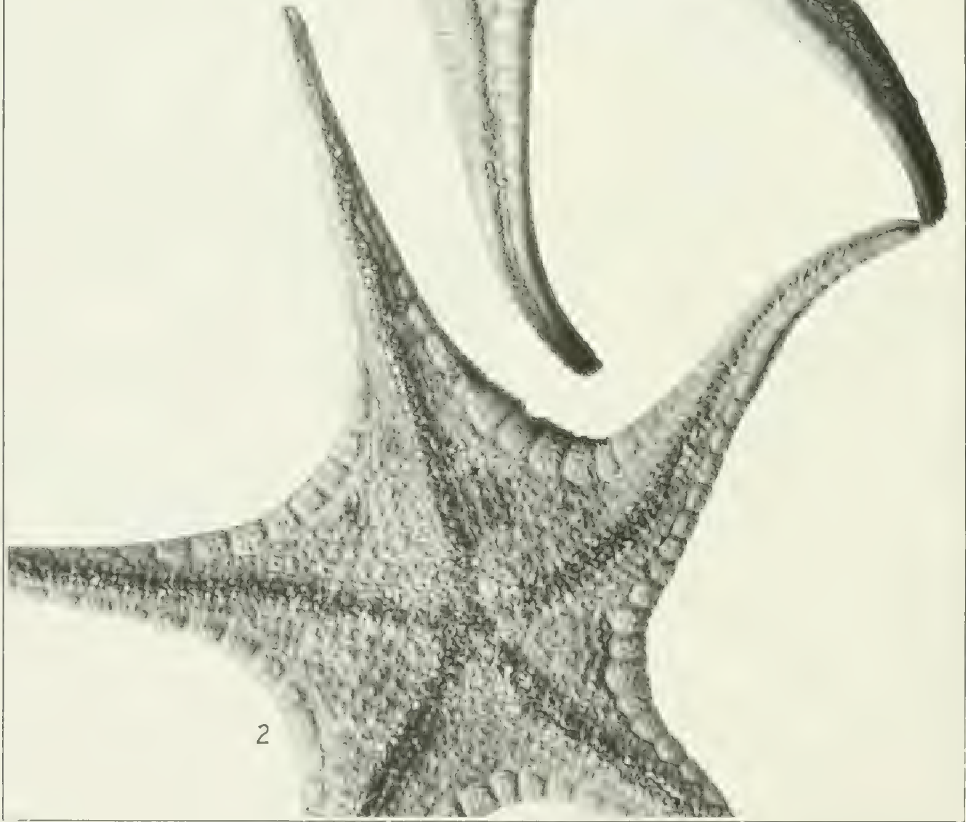
Plate 81.

Fig. 1. *Astroceramus lionotus;* abactinal aspect of type, p. 310.
2. *Astroceramus sphaeriostictus;* abactinal aspect of type, p. 313.
3. *Iconaster perierctus;* actinal view of type, p. 306.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.





Starfishes of the Philippine Seas and Adjacent Waters.

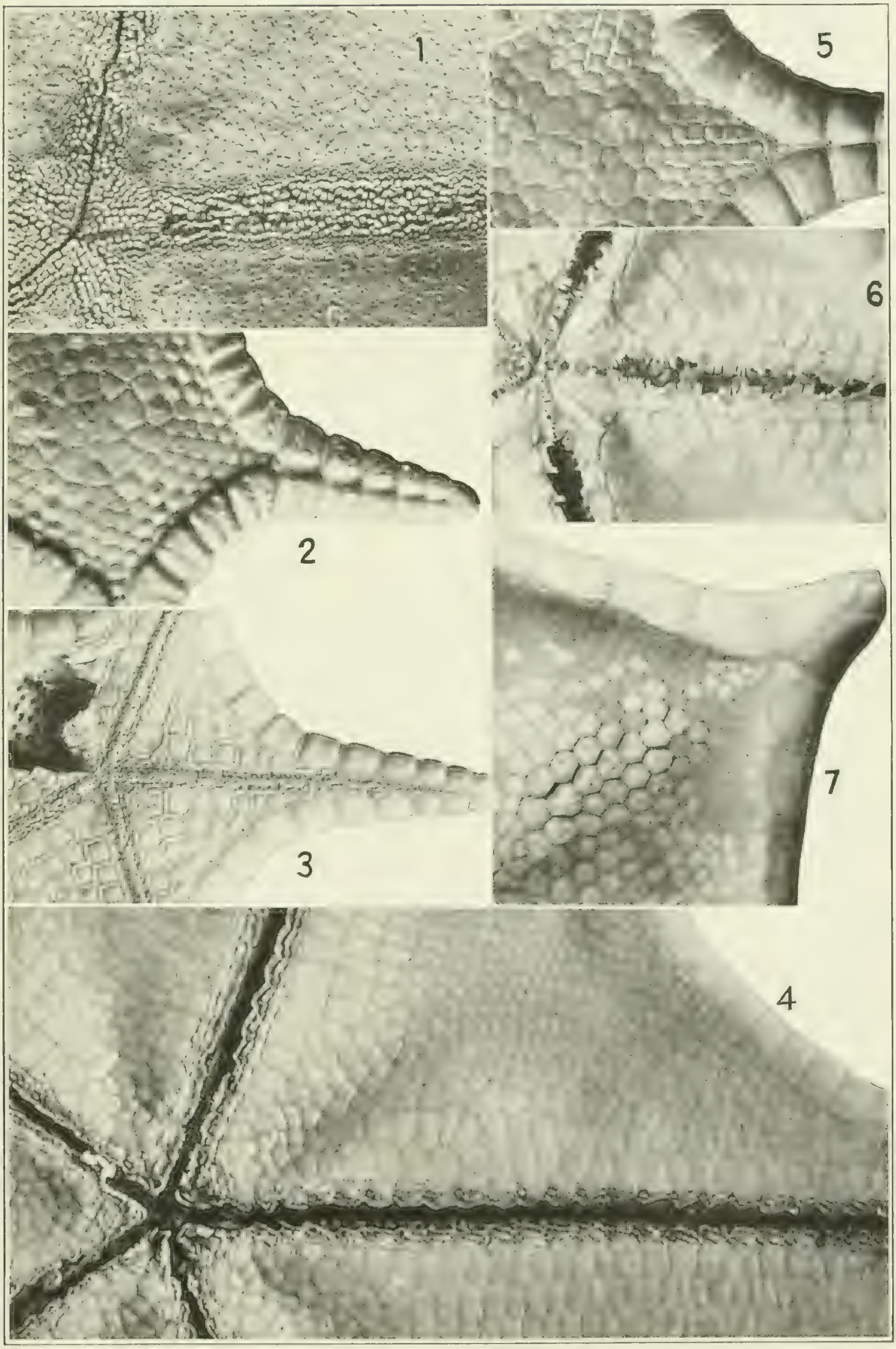
Plate 82.

Fig. 1. *Astroceramus lionotus;* actinal view of type, p. 310.
2. *Astroceramus sphaeriostictus;* actinal view of type, p. 313.

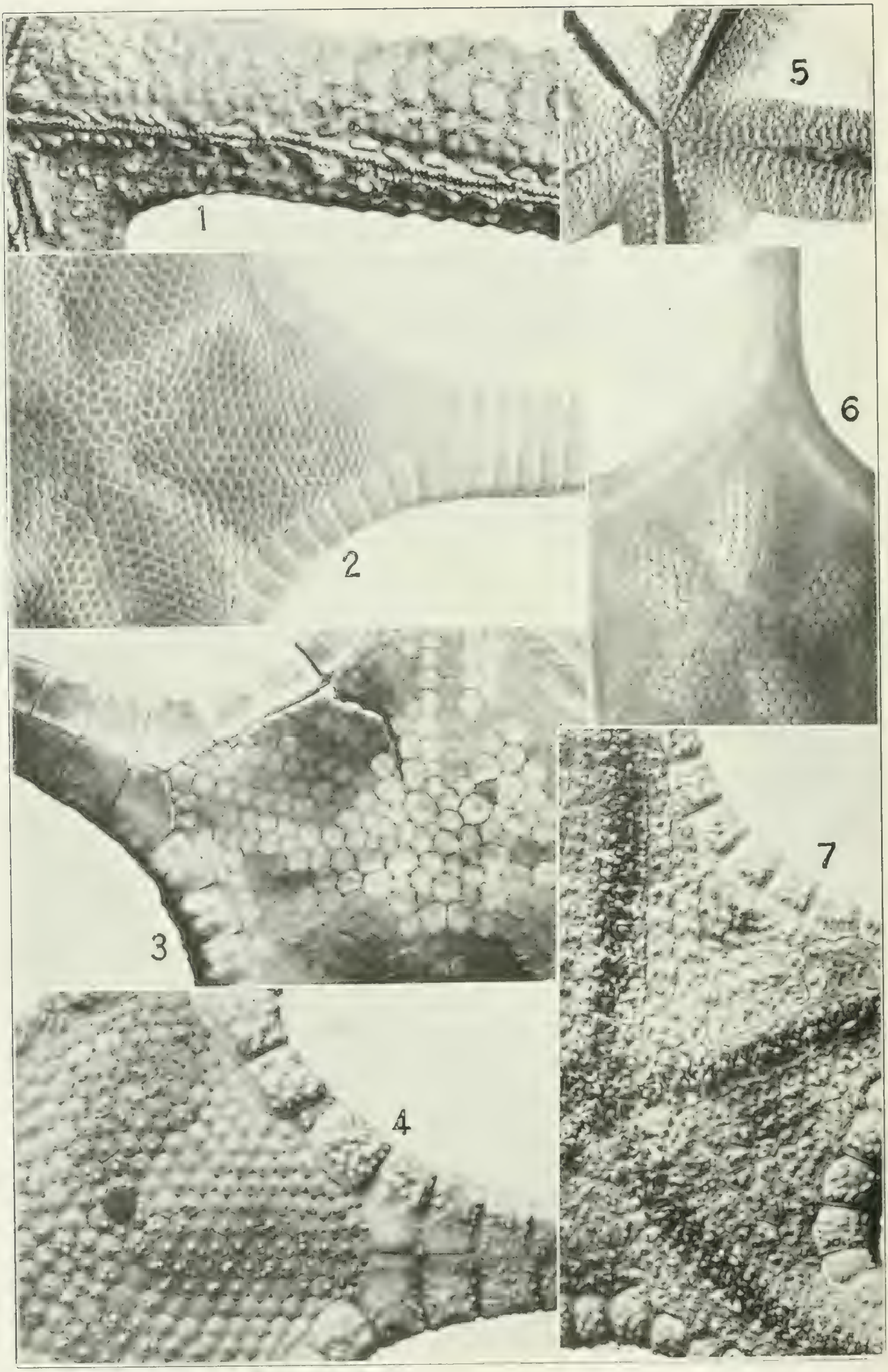
PLATE 83.

Enlarged details, both surfaces.

FIG. 1. *Pellaster cycloplax;* actinal, mouth to left, p. 290.
2. *Iconaster perierctus;* abactinal, p. 306.
3. Same: actinal.
4. *Pontioceramus grandis;* actinal, p. 294.
5. *Iconaster longimanus;* abactinal, p. 303.
6. *Sphaeriodiscus scotocryptus;* actinal, p. 287.
7. Same; abactinal.



Starfishes of the Philippine Seas and Adjacent Waters.



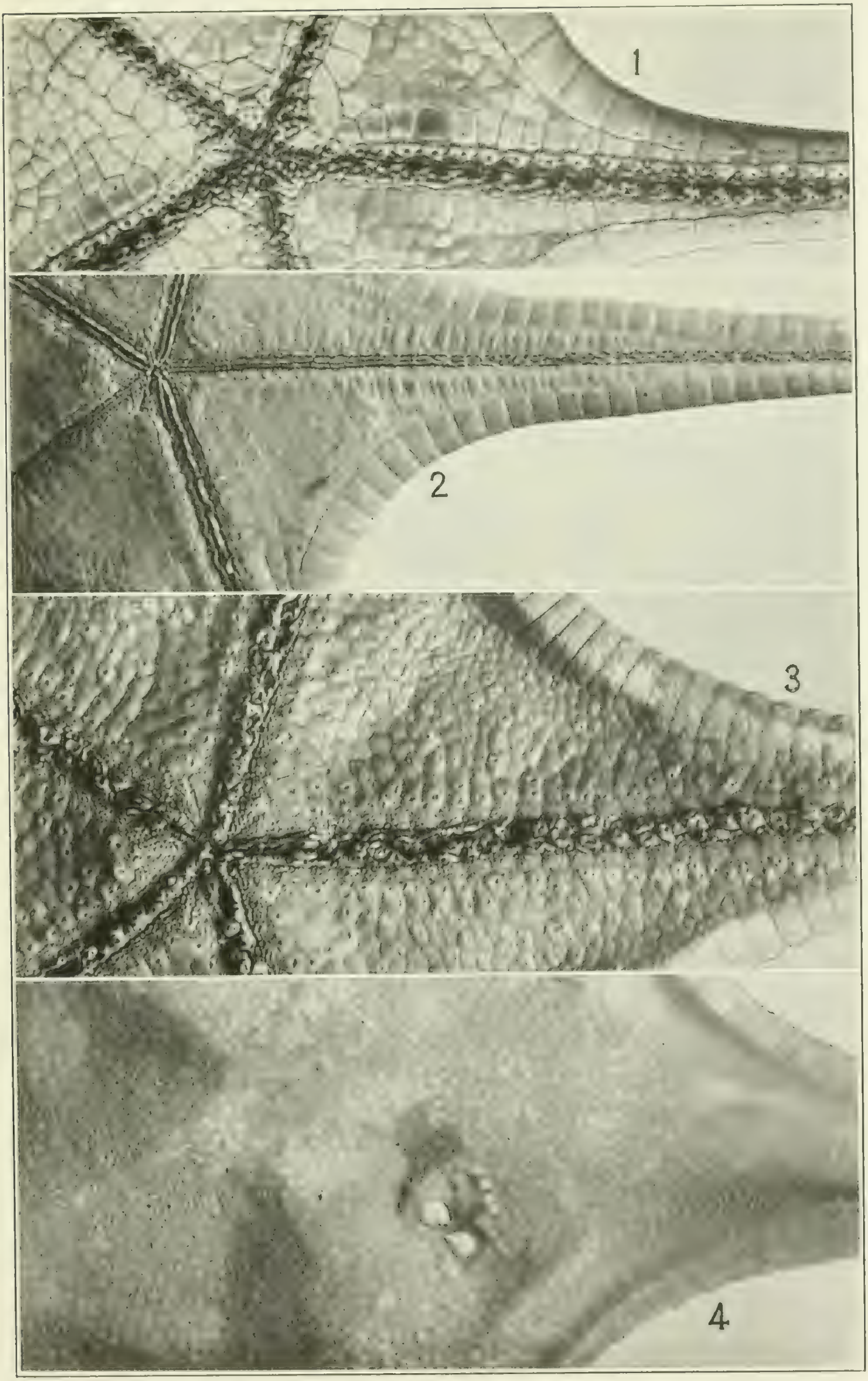
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 81.

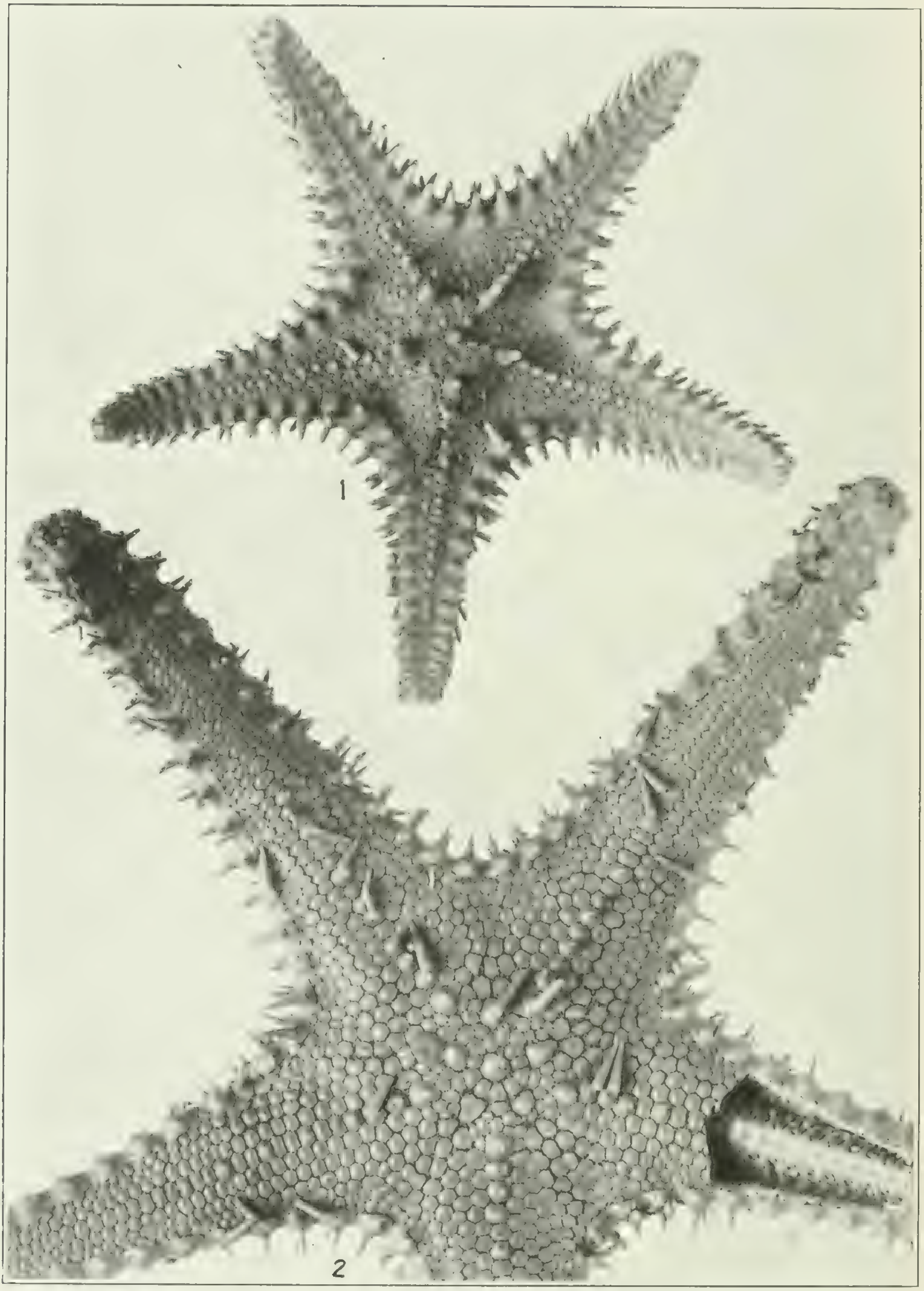
FIG. 1. *Leiaster analogus;* actinal surface dried, enlarged, p. 396.
2. *Lithosoma actinometra;* abactinal, natural size, p. 298.
3. *Astroceramus linonotus;* abactinal, p. 310.
4. *Astroceramus sphaeriostictus;* abactinal, p. 313.
5. *Ophidiaster trychnus;* actinal, enlarged, p. 390.
6. *Lithosoma penichra;* abactinal, slightly enlarged, p. 301.
7. *Astroceramus sphaeriostictus;* actinal, p. 313.

PLATE 85.

FIG. 1. *Lithosoma penichra;* actinal surface, enlarged (r=21 mm.), p. 301.
2. *Lithosoma actinometra;* actinal surface, slightly reduced, p. 298.
3. *Atelorias anacanthus;* actinal, p. 343.
4. *Anthenoides rugulosus;* abactinal, p. 338.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



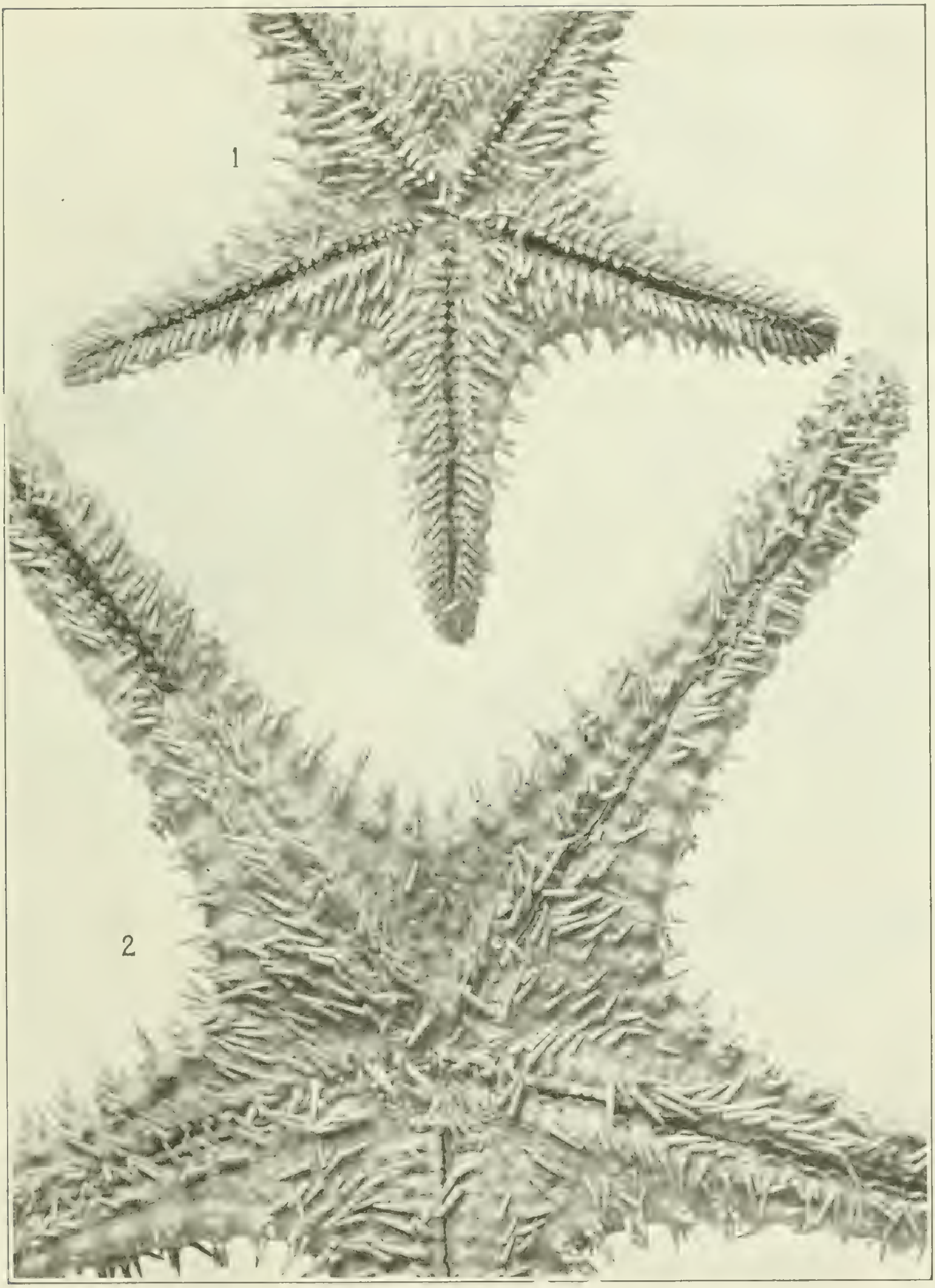
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 86.

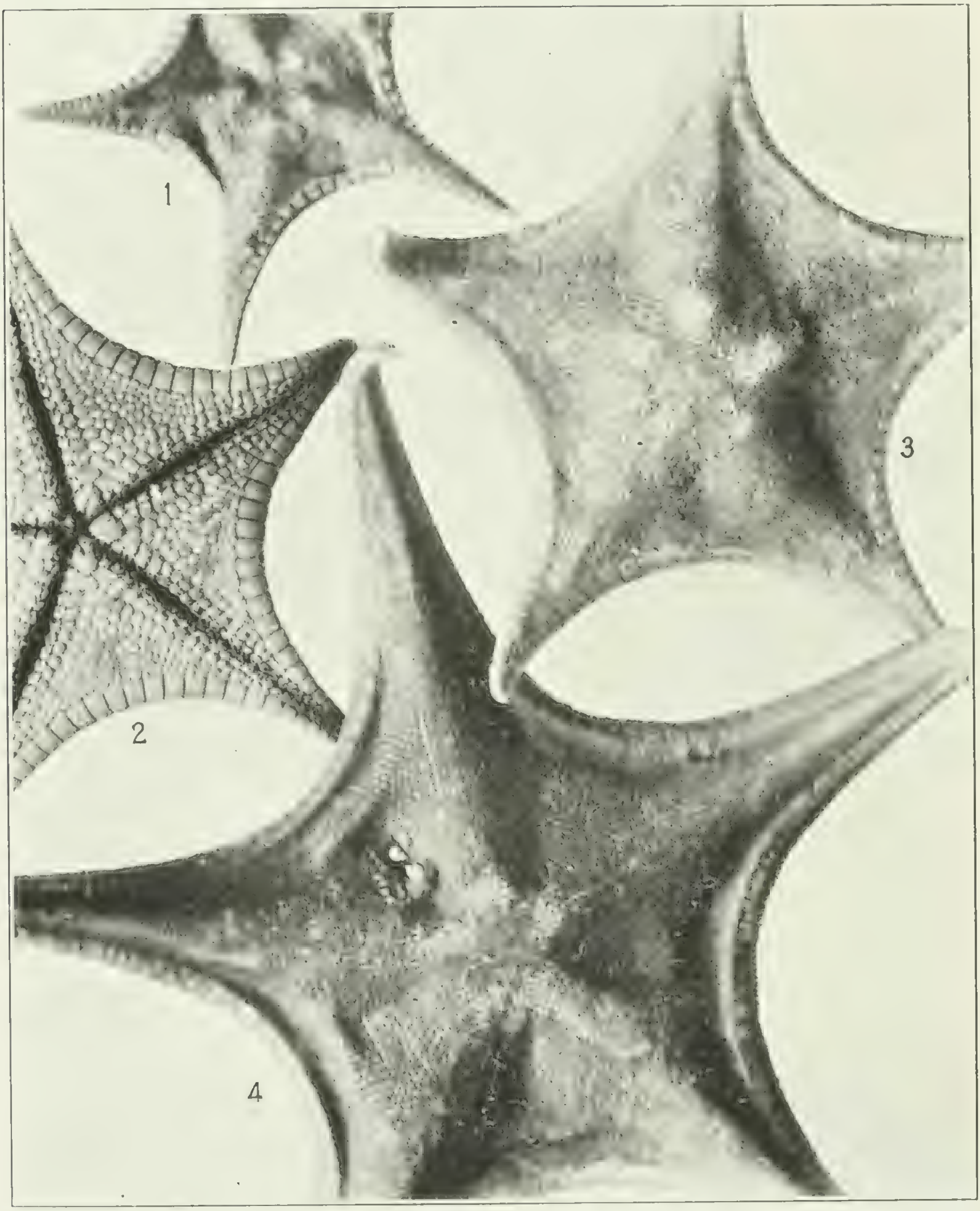
FIG. 1. *Calliaster corynetes;* abactinal view of type, p. 316.
2. *Astrothauma euphylacteum;* abactinal aspect of type, p. 320.

PLATE 87.

FIG. 1. *Calliaster corynetes;* actinal view of type, p. 316.
2. *Astrothauma euphylacteum;* actinal view of type, p. 320.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 88.

FIG. 1. *Anthenoides cristatus;* young specimen, reduced, p. 327.

2. *Anthenoides granulosus;* actinal surface of a dried specimen, reduced, p. 333.

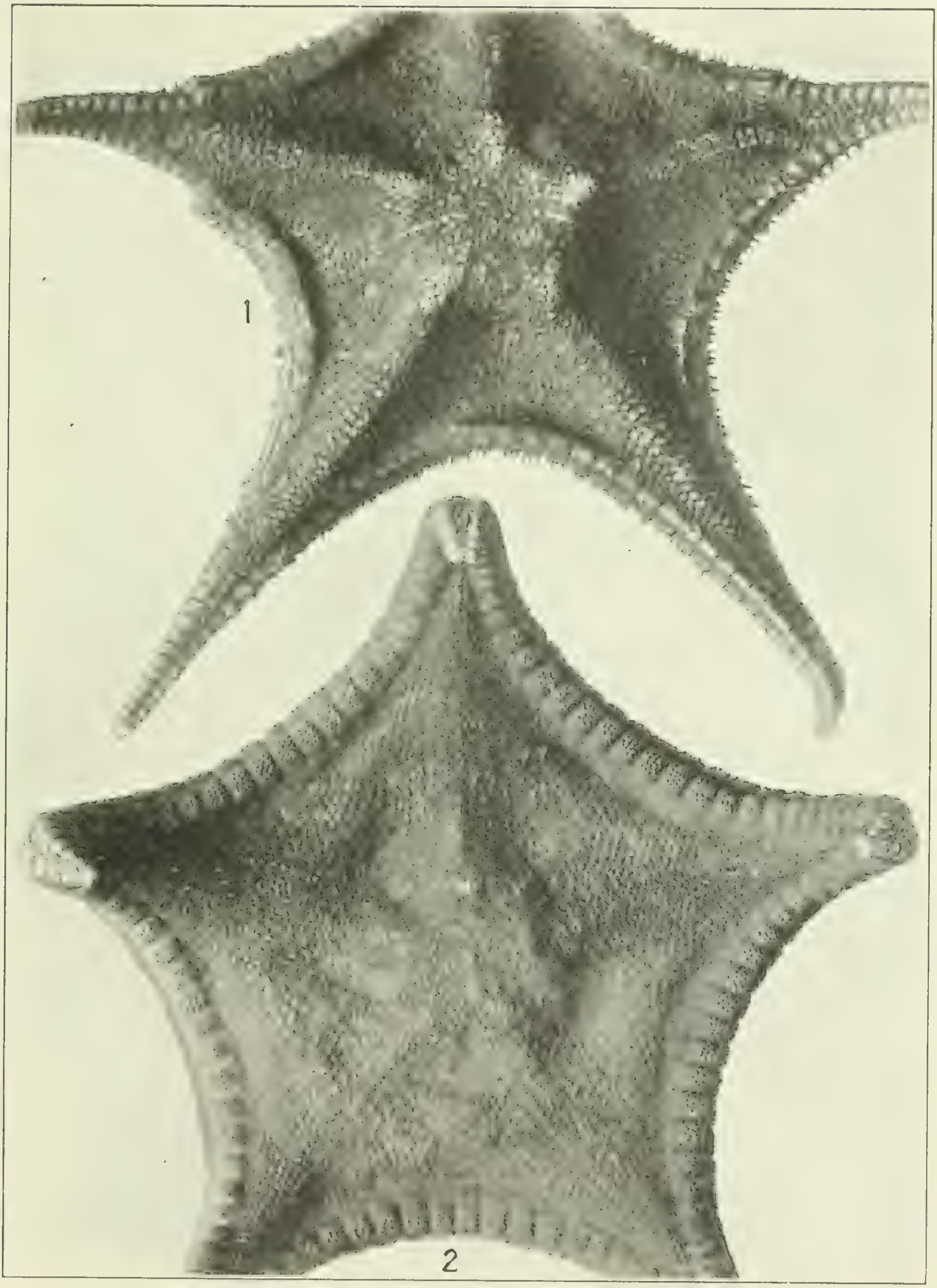
3. Same; abactinal aspect of type, reduced.

4. *Anthenoides rugulosus;* abactinal view of type, reduced, p. 338.

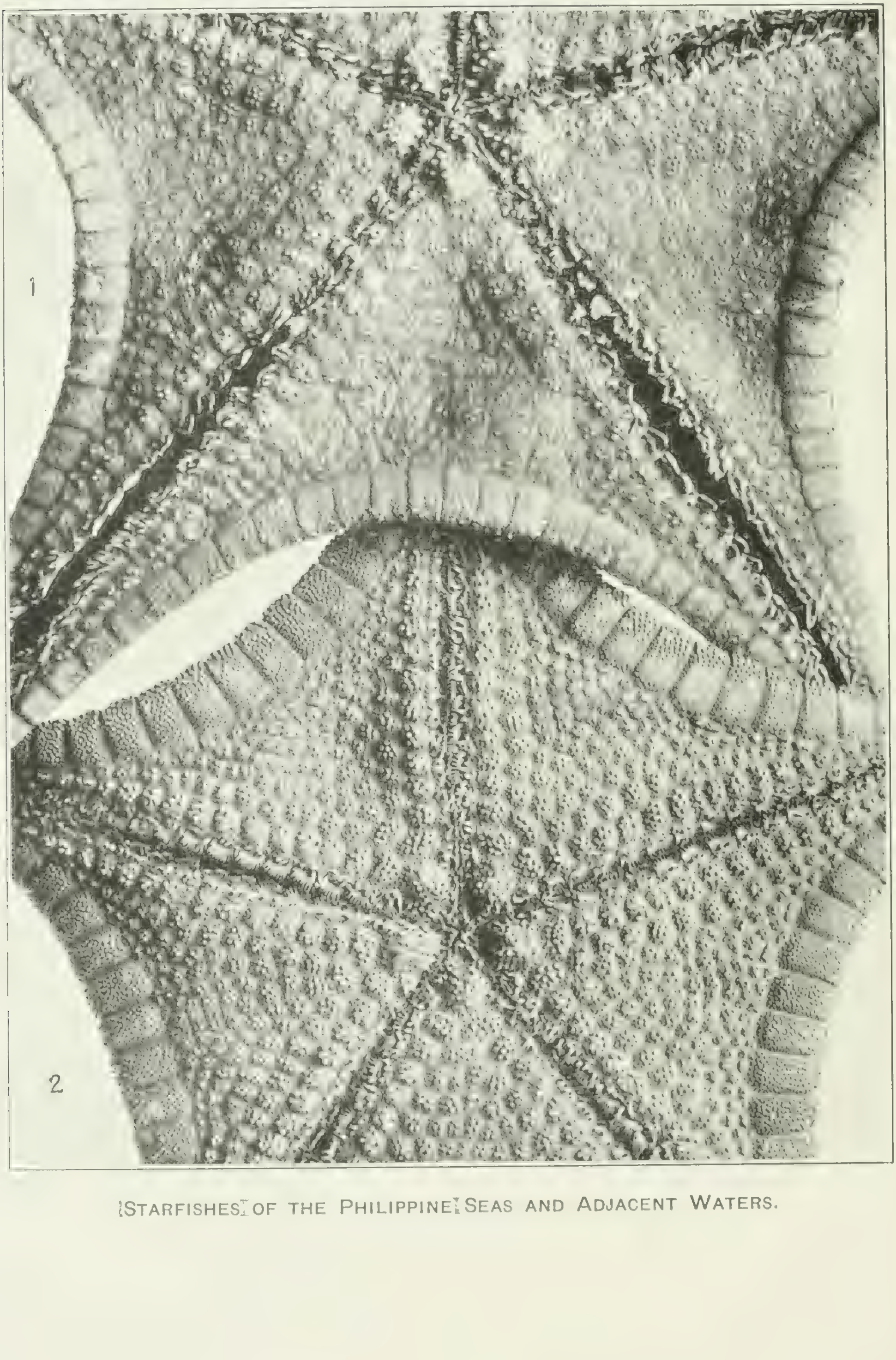
PLATE 89.

FIG. 1. *Anthenoides cristatus;* abactinal view of full-grown specimen, reduced, p. 329.

2. *Anthenoides lithosorus;* abactinal aspect of type, reduced, p. 336.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 90.

FIG. 1. *Anthenoides rugulosus;* actinal surface of type, enlarged, p. 338.

2. *Anthenoides lithosorus;* actinal surface of type (dry), enlarged, p. 336.

PLATE 91.

FIG. 1. *Aphroditaster microceramus*, type; 3 abactinal plates, radial region, × 9.6. 1*a*. Same; an abactinal plate from side, × 9.6. P. 225.

2. *Pseudarchaster oligoporus*, type; fifth adambulacral plate, and 3 adjacent actinal intermediate plates. 2*a*. Same; 2 abactinal plates, × 9.6. P. 222.

3. *Rosaster nannus*, type; 2 proximal adambulacral plates, × 9.6. 3*a*. Same; median radial plate, adjacent to the primary radial, × 20. 3*b*. Same; abactinal plates from the coelomic side; *a*, anus; *r—a*, radial line of plates; *ir—a*, interradial line of plates. P. 244.

4. *Rosaster mimicus*, type; seventh adambulacral plate, and parts of 2 adjacent actinal plates. 4*a*. Same; an actinal intermediate pedicellaria. 4*b*. Same; abactinal plates from the coelomic side; *r—r*, radial plates; 2 plates of either adradial series are shown, and several plates from the interradial region, × 6.5. P. 250.

5. *Rosaster mamillatus*, type; a radial (left) and 2 adradial plates, × 9.6. 5*a*. Same; fourth superomarginal from tip of ray showing the tubercle; to the right, 2 abactinal plates are shown which separate the 2 series of superomarginals, × 9.6. P. 247.

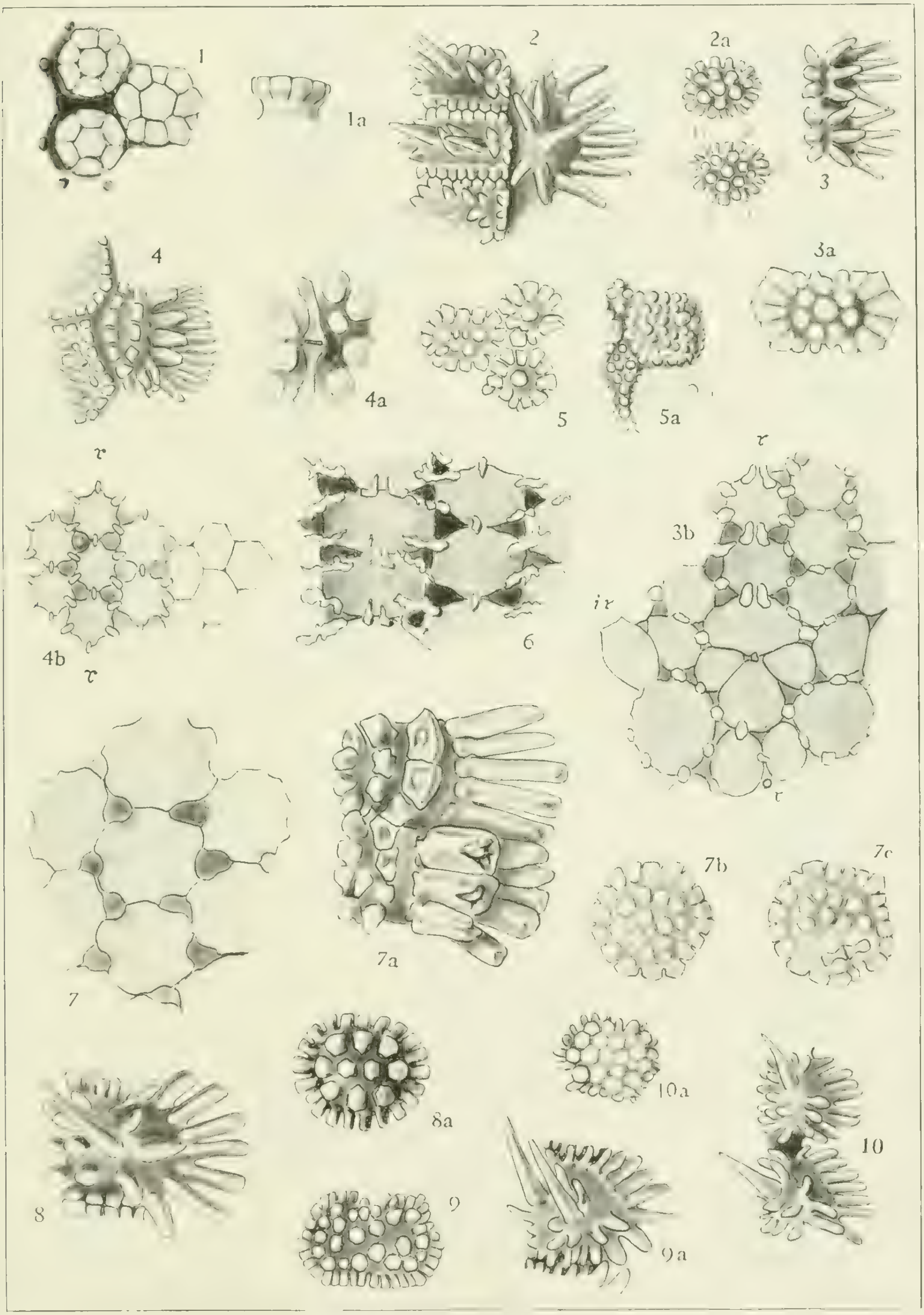
6. *Rosaster symbolicus;* 3 radial plates to the left, and 2 adradial to the right, showing the internal connecting ossicles, × 6.5. P. 253.

7. *Ceramaster smithi*, type; abactinal plates of radial area from coelomic side, × 9.6. 7*a*. Same; fourteenth and fifteenth adambulacral plates, × 9.6. 7*b*. Same; one of the proximal radial plates, × 9.6. 7*c*. Same; an adradial plate, × 9.6. P. 257.

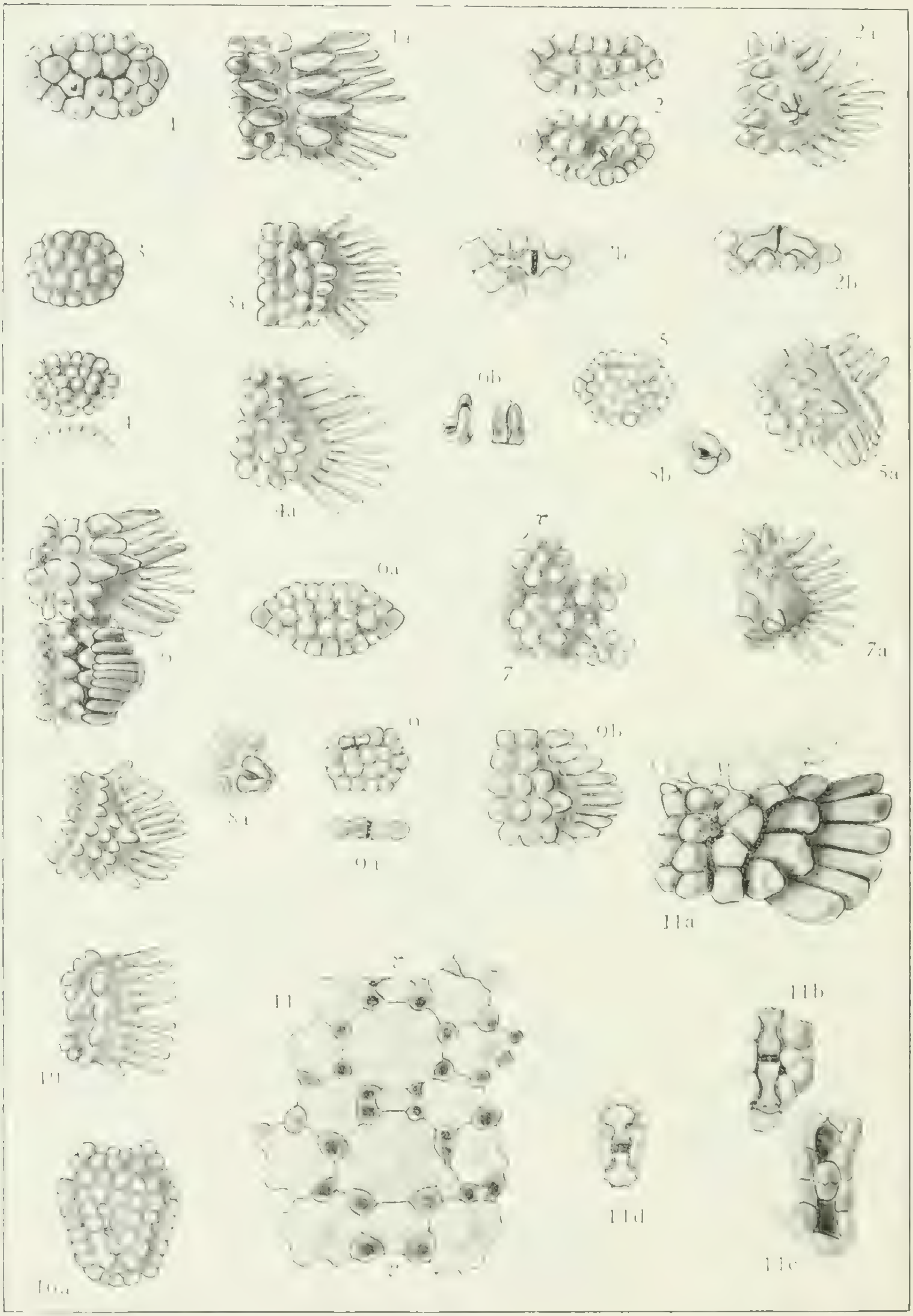
8. *Perissogonaster insignis*, type; twentieth adambulacral plate, × 6.5. 8*a*. Same; radial paxilla from disk, × 9.6. P. 236.

9. *Paragonaster ctenipes hypacanthus;* radial paxilla or plate, × 9.6. 9*a*. Same; seventh adambulacral plate, × 6.5. P. 228.

10. *Paragonaster stenostichus*, type; fifth and sixth adambulacral plates, × 9.6. 10*a*. Same; a paxilla from the radial series, × 9.6. P. 232.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 92.

FIG. 1. *Nymphaster mucronatus*, type; a radial abactinal plate from midway between center and base of ray, × 9.6. 1*a*. Same; thirteenth adambulacral plate, × 6.5. P. 269.

2. *Nymphaster leptodomus*, type; 2 consecutive radial plates, × 9.6. 2*a*. Same; sixteenth adambulacral plate, × 9.6. 2*b*. Same; abactinal pedicellaria, × 12. P. 272.

3. *Nymphaster moluccanus*, type; radial plate, from middle of radial area, × 6.5. 3*a*. Same; seventeenth adambulacral plate, × 6.5. 3*b*. Same; actinal intermediate pedicellaria from plates adjacent to adambulacrals. P. 274.

4. *Nymphaster meseres*, type; radial plate, × 9.6. 4*a*. Same; tenth adambulacral plate (the first to touch an inferomarginal plate), × 9.6. P. 280.

5. *Nymphaster dyscritus*, type; proximal radial plate, × 6.5. 5*a*. Same; sixteenth adambulacral plate, × 6.5. 5*b*. Same; pedicellaria from an adambulacral plate. P. 266.

6. *Nymphaster euryplax*, type; sixteenth and seventeenth adambulacral plates, the latter being the first to touch an inferomarginal at base of ray, × 6.5. 6*a*. Same; radial plate from middle or radial area, × 6.5. 6*b*. Same; pedicellaria. P. 264.

7. *Nymphaster atopus*, type; abactinal plates from radial area, × 9.6. 7*a*. Same; sixth adambulacral plate (the last one adjacent to an actinal intermediate plate), × 9.6. P. 285.

8. *Nymphaster habrotatus*, type; fifteenth adambulacral plate, × 6.5. 8*a*. Same; pedicellaria on third adambulacral plate. P. 282.

9. *Nymphaster anthrocnemis*, type; a proximal radial plate, × 6.5, and below an abactinal pedicellaria much enlarged. 9*b*. Same; twelfth adambulacral plate. P. 277.

10. *Sphaeriodiscus scotocryptus*, type; fourth adambulacral plate, × 9.6 10*a*. Same; proximal radial plate, × 9.6. P. 287.

11. *Peltaster cycloplax*, type; radial plates, with secondary plates, from the coelomic side, × 6.5. 11*a*. Same; eighth adambulacral plate, × 6.5. 11*b*. Same; actinal intermediate pedicellaria, open. 11*c*. Same; closed, × 9.6. 11*d*. Same; abactinal pedicellaria, × 9.6. P. 290.

PLATE 93.

FIG. 1. *Iconaster perierctus*, type; primary radial plate (*pr*), 2 radial plates, and 2 adradial plates. 1*a*. Same; ninth and tenth adambulacral plates. P. 306.

2. *Iconaster longimanus;* 2 radial plates (*r*), and 2 lateral series, showing the peculiar marginal granules and pedicellariae, × 9.6. 2*a*. Same; fifteenth adambulacral plate (at base of narrow part of ray), × 9.6. P. 303.

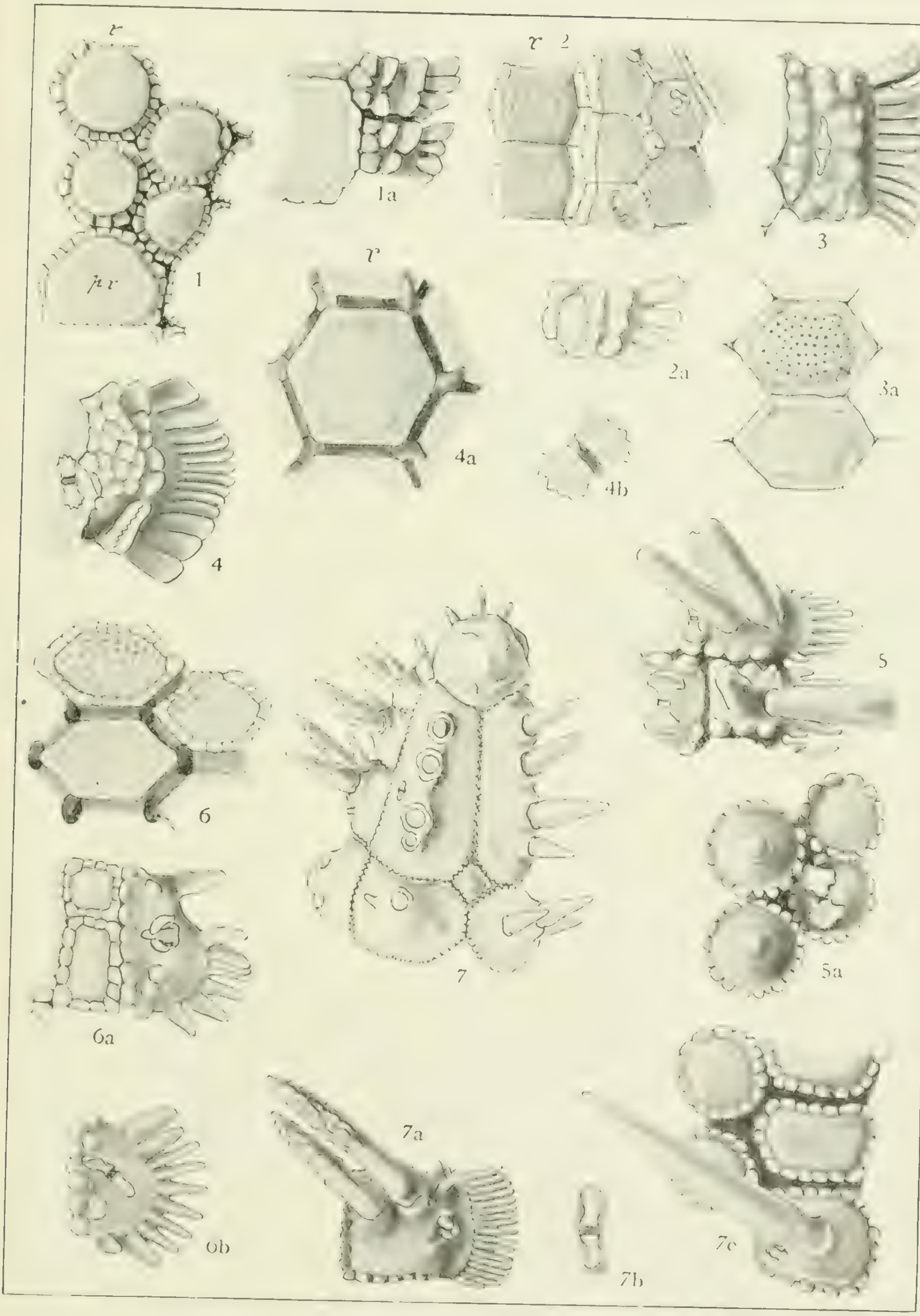
3. *Lithosoma actinometra*, type; tenth adambulacral plate, × 6.5. 3*a*. Same; 2 radial plates, × 6.5. P. 298.

4. *Pontioceramus grandis*, type; twentieth adambulacral plate, × 6.5. 4*a*. Same; radial plate near center of disk, × 6.5. 4*b*. Same; an actinal intermediate pedicellaria, × 9.6. P. 294.

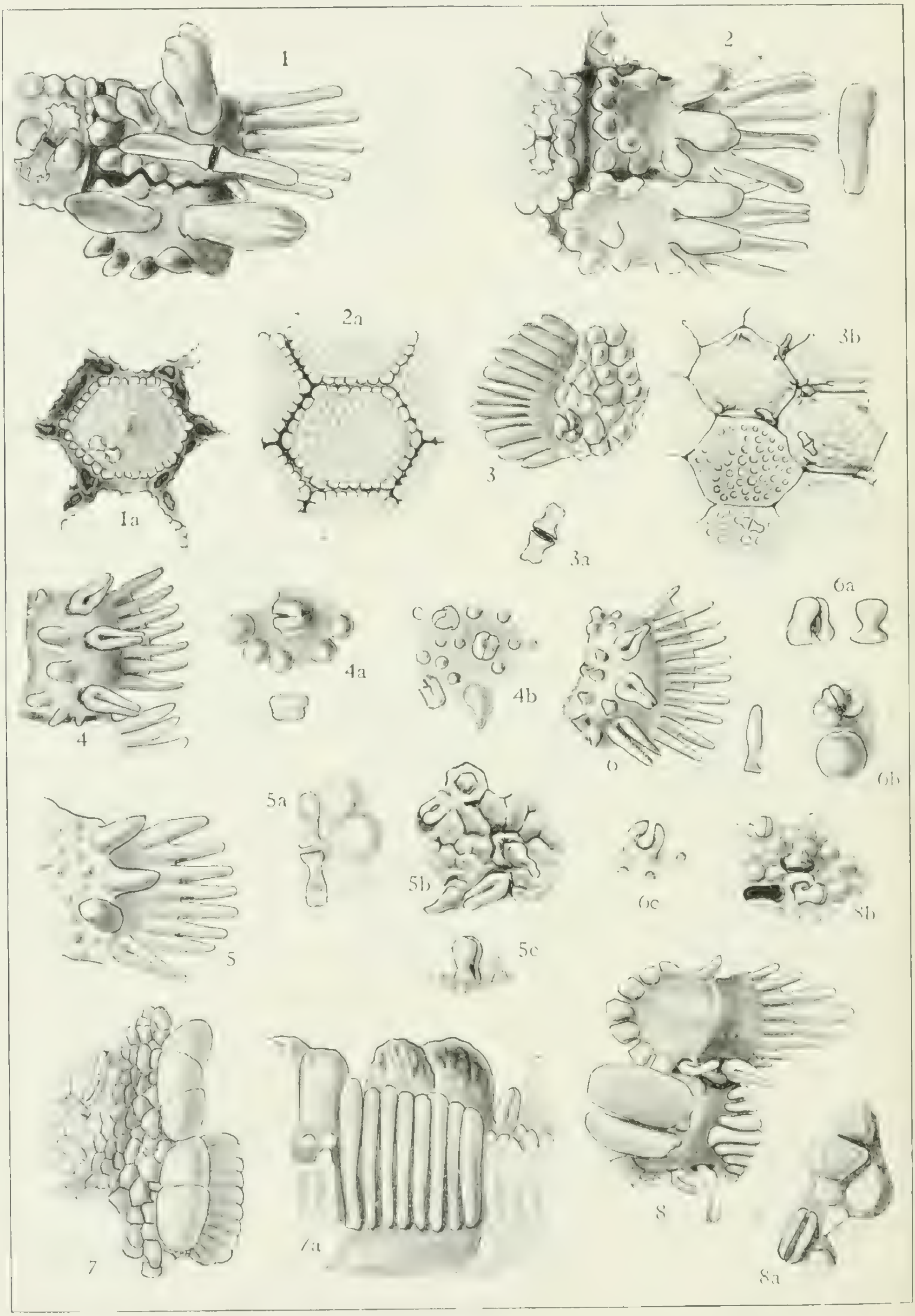
5. *Calliaster corynetes*, type; eighth and ninth adambulacral plates, and × 9.6 5*a*. Same, station 5248; furrow face of adambulacral plates. Same; abactinal plates, the 2 on the left being the third and fourth from the primary radial; lower plate adcentral, × 6.5. P. 316.

6. *Lithosoma penichra*, type; the 2 plates to the left are from the radial series; 1 adradial plate with pedicellaria, × 9.6. 6*a*. Same; fourteenth adambulacral, and 2 adjacent actinal plates, × 9.6. 6*b*. Same; from station 5123; corresponding plate to that shown in 6*a*, × 9.6. P. 301.

7. *Astrothauma euphylacteum*, type; tip of ray, showing the enlarged distal superomarginals, × 3.2. 7*a*. Same; adambulacral plate, × 6.5. 7*b*. Same; actinal intermediate pedicellaria, enlarged. 7*c*. Same; on right, fourth to sixth radial plate from the primary radial; 2 adradials on the left, × 6.5. P. 320.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 94.

Fig. 1. *Astroceramus sphaeriostictus*, type; fourth and fifth adambulacral plates and adjacent actinal plate, × 9.6. 1*a*. Same; a radial plate, × 6.5. P. 315.

2. *Astroceramus lionotus*, type; fourth and fifth adambulacral plates and adjacent actinal plate, × 9.6. 2*a*. Same; 2 radial plates, × 6.5. P. 310.

3. *Atelorias anacanthus*, type; sixth adambulacral plate. 3*a*. Same; actinal pedicellaria near adambulacrals. 3*b*. Same; radial plates; 2 plates have been treated with caustic potash to show granules, × 6.5. P. 343.

4. *Anthenoides granulosus*, station 5624; seventh adambulacral plate, × 6.5. 4*a*. Same; an actinal pedicellaria; below, one jaw from side, × 12. 4*b*. Same; abactinal pedicellariae, dry, × 9.6. P. 333.

5. *Anthenoides rugulosus*, type; seventh adambulacral plate; specimen not dry. × 5. 5*a*. Same; actinal pedicellaria adjacent to adambulacral plate, × 12. 5*b*. Same; small portion of abactinal surface in radial region, showing 2 pedicellariae and wrinkled skin, × 12; *p.*, papulae; *pd.*, pedicellariae. 5*c*. Same; closed pedicellaria. P. 338.

6. *Anthenoides lithosorus*, type, dried; eighth adambulacral plate, × 5. 6*a*. Same; actinal intermediate pedicellariae, adjacent to furrow, × 9.6. P. 336.

6*b*. Same; a pedicellaria and a granule, × 9.6. 6*c*. Same; abactinal pedicellaria from side, × 16.

7. *Halityle regularis*, type; actinal view of 2 adambulacral plates, and a portion of an intermediate plate, × 5. 7*a*. Same; dried specimen; furrow face of an adambulacral plate; on either side the furrow spines have been removed to show actinal surface, × 9.6. P. 362.

8. *Pentaceropsis tyloderma*, type; 2 adamblacral plates from middle of ray, furrow margin to right; the subambulacral spines have been removed from the distal plate, × 6.5. 8*a*. Same; actinal intermediate pedicellaria opposite third adambulacral plate, × 9.6. 8*b*. Same; abactinal pedicellariae from papular area, middle of radial region, much enlarged. P. 350.

PLATE 95.

FIG. 1. *Asterodiscus helonotus*, type; tubercles on central portion of disk, × 6. 1*a*. Same; 2 adambulacral plates, × 6.5. P. 357.

2. *Fromia eusticha*, type; fourteenth and fifteenth plates, × 9.6. P. 375.

3. *Fromia hemiopla*, type; 2 adambulacral plates from proximal third of ray, × 9.6. P. 377.

4. *Ferdina glyptodisca*, type; furrow face of an adambulacral plate, middle of ray, the adoral side to right, × 9.6. 4*a*. Same; the adambulacral spines seen from the actinal surface; the dotted lines indicate the limits of a plate; adoral side of plate, below, × 9.6. 4*b*. Same; integument adjacent to basal plate (part of which is shown on the left) showing the granules, × 9.6. P. 370.

5. *Ophidiaster fuscus*, station 5248; actinal view of 3 adambulacral plates, × 9.6. 5*a*. Same, station 5248;; furrow face of adambulacral plates, × 9.6. 5*b*. Same; an adradial plate, showing tubercle, pedicellaria, and adjacent papular area, × 9.6. 5*c*. Same, station 5641; a pedicellaria, enlarged. P. 388.

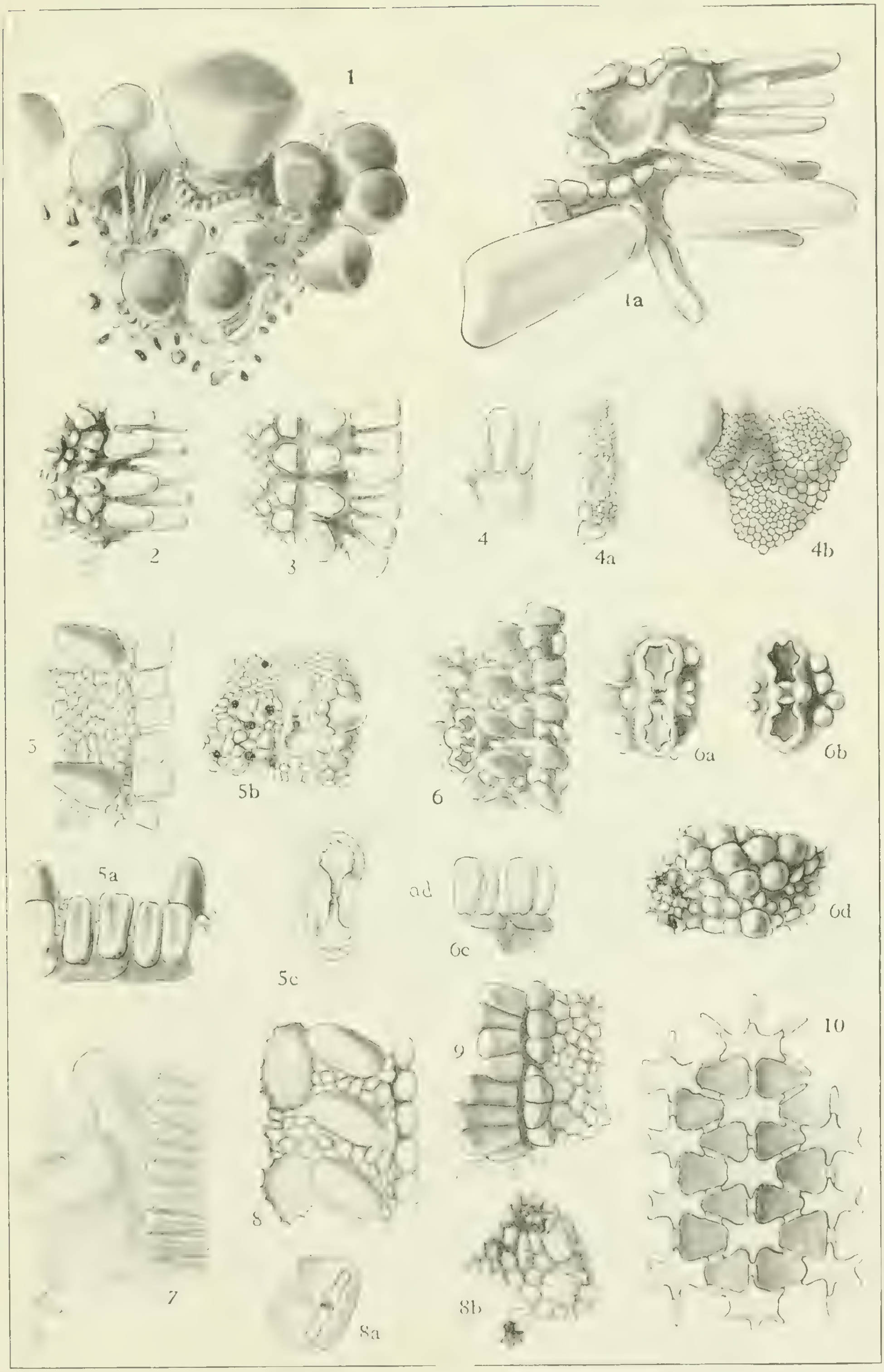
6. *Ophidiaster trychnus*, type; adambulacral plates, base of ray, × 16. 6*a*. Same, cotype; an abactinal pedicellaria, × 16. 6*b*. Same, cotype; the form or alveolus of an abactinal pedicellaria, × 16. 6*c*. Same, type; furrow face of 2 adambulacral plates, × 16; *ad*., adoral side. 6*d*. Same, type; radial plates, near base of ray, × 16. P. 390.

7. *Leiaster analogus*, station 5165, dried; adambulacral plates, × 9.6. P. 396.

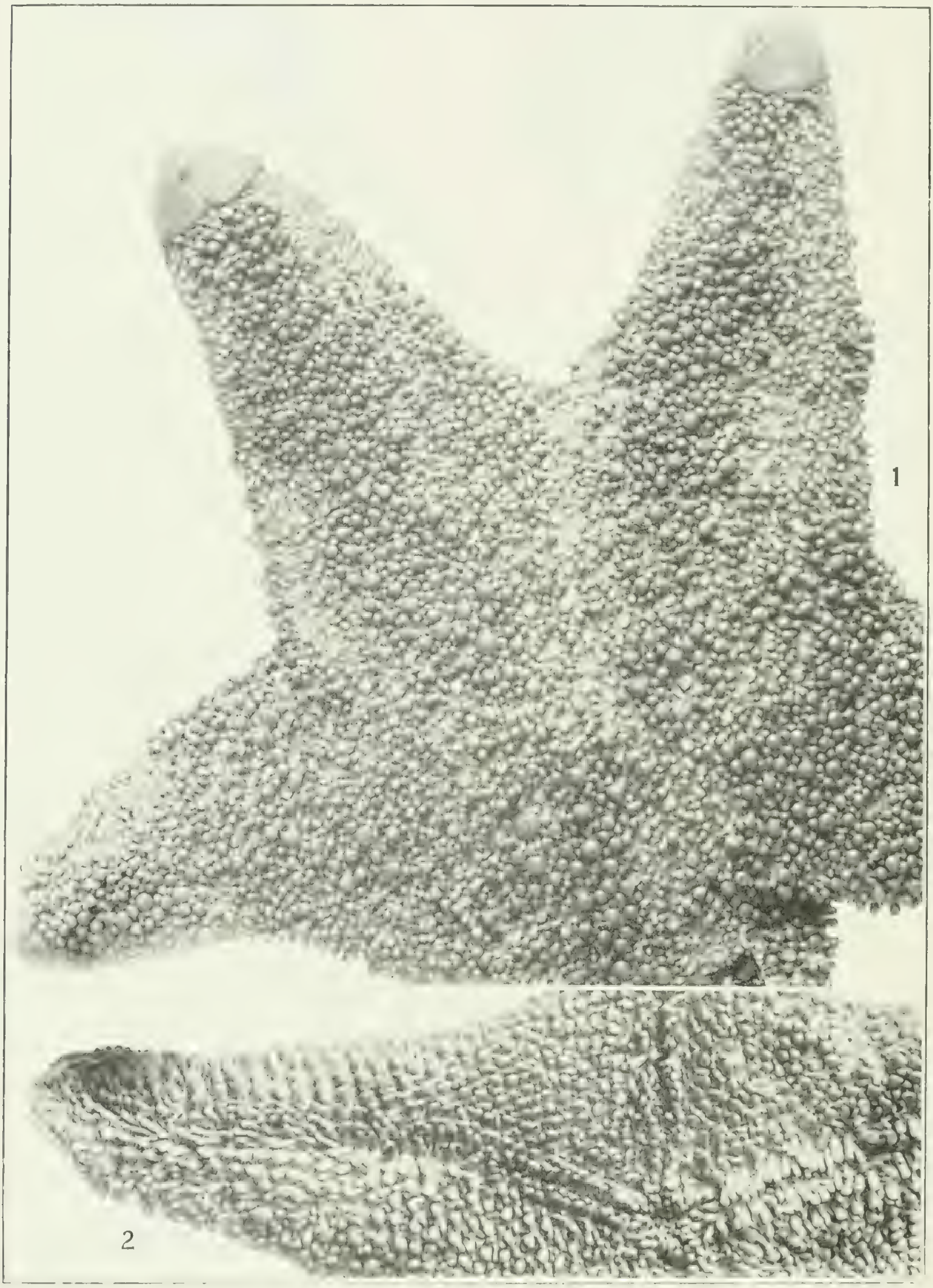
8. *Bunaster lithodes*, type; actinal surface, near base of ray, × 12; adambulacral plates to right; the subambulacral spines are in the middle. 8*a*. Same; a pedicellaria from an abactinal plate, in an interradius, much enlarged. 8*b*. Same; abactinal granules and pedicellariae, much enlarged. P. 398.

9. *Nardoa tumulosa*, station 5160; 2 adambulacral plates near middle of ray, × 6.5. P. 386.

10. *Halityle regularis*; abactinal plates from the middle of the radial region, and from the coelomic side, natural size. P. 362.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

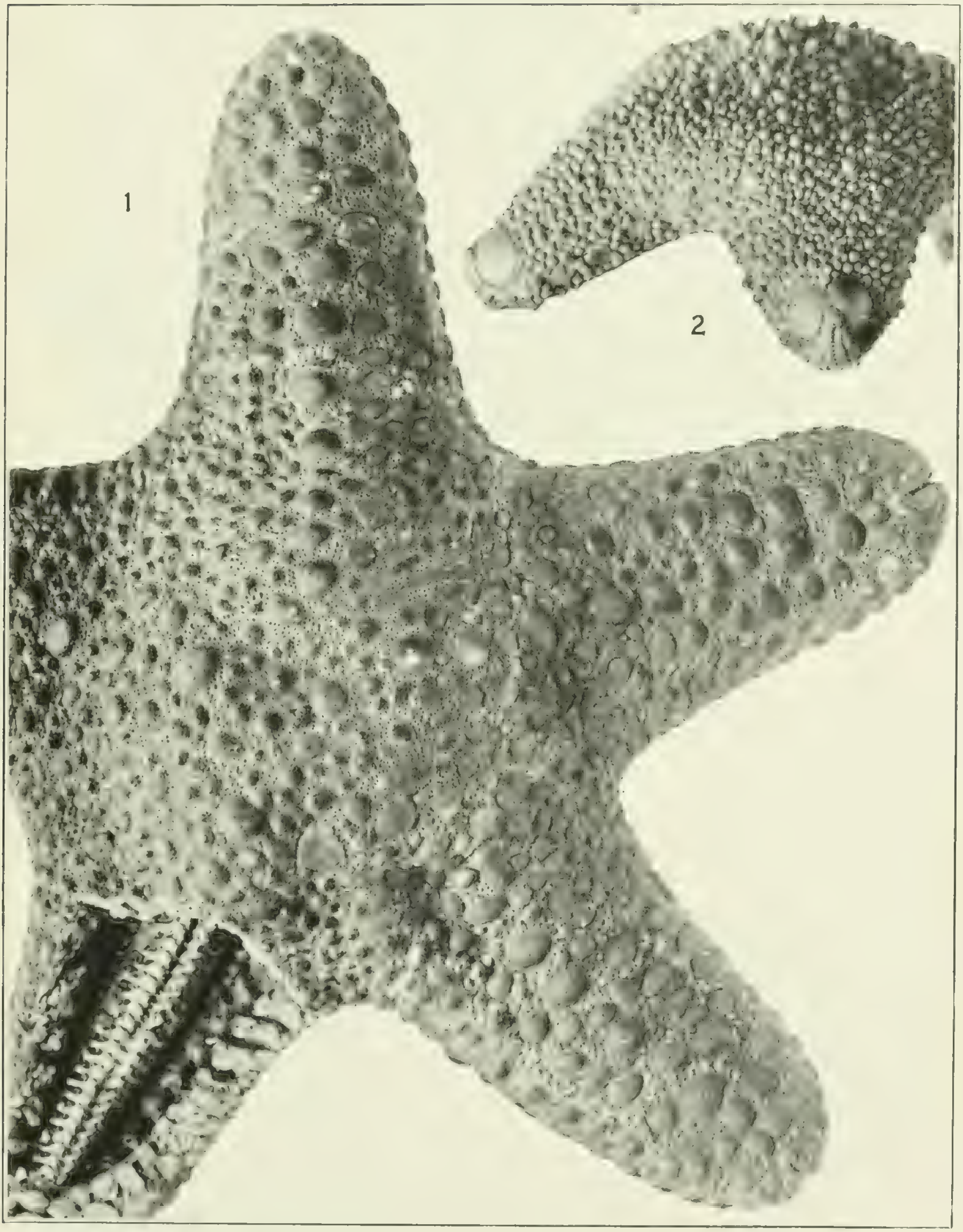
PLATE 96.

FIG. 1. *Asterodiscus helonotus*, type; abactinal surface, p. 357.

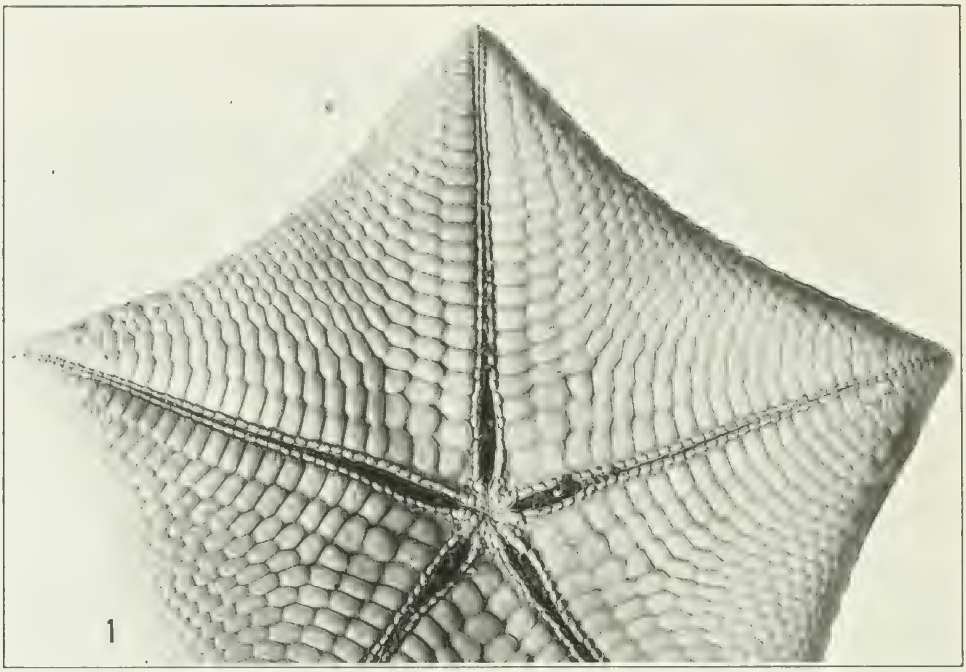
2. Same; portion of actinal surface.

PLATE 97.

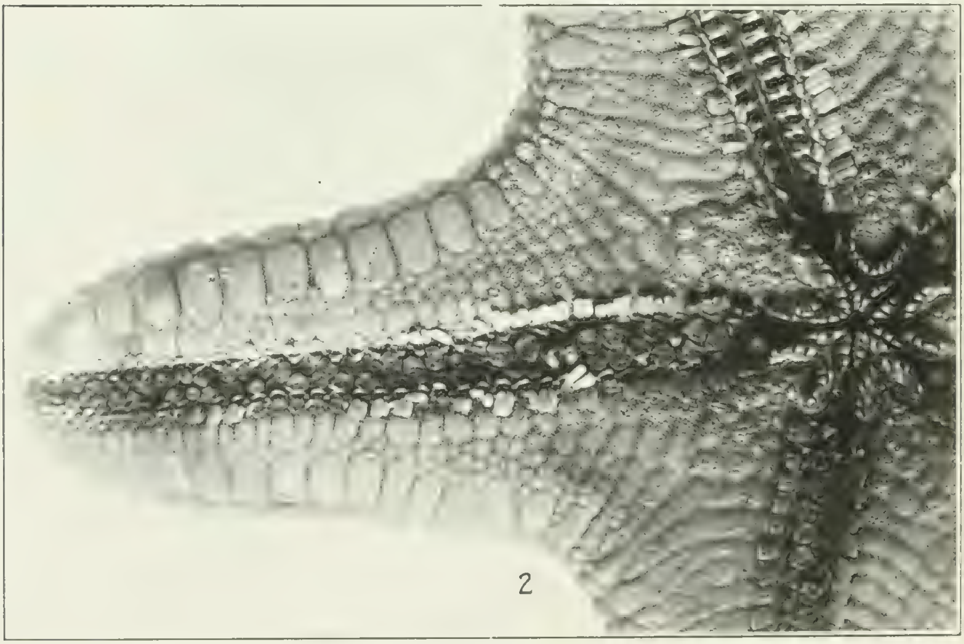
FIG. 1. *Pentaceropsis tyloderma*, type; abactinal surface, p. 350.
2. *Asterodiscus elegans;* specimen photographed from side, p. 355.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



1



2

STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 98.

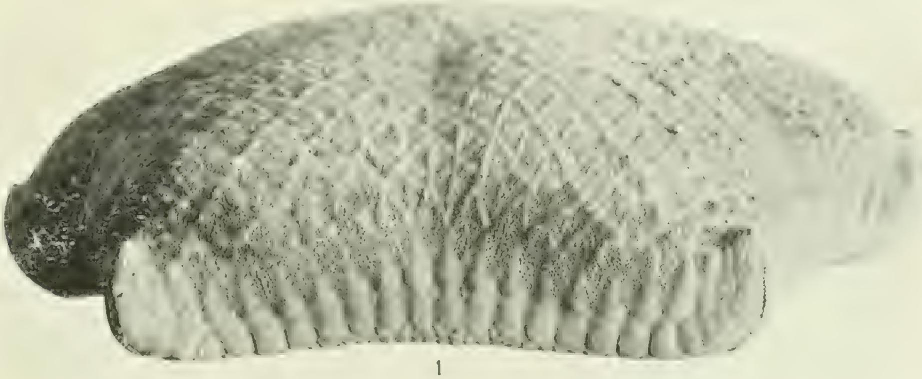
FIG. 1. *Halityle regularis;* actinal surface of type, reduced, p. 362.
2. *Pentaceropsis tyloderma;* actinal surface of type, p. 350.

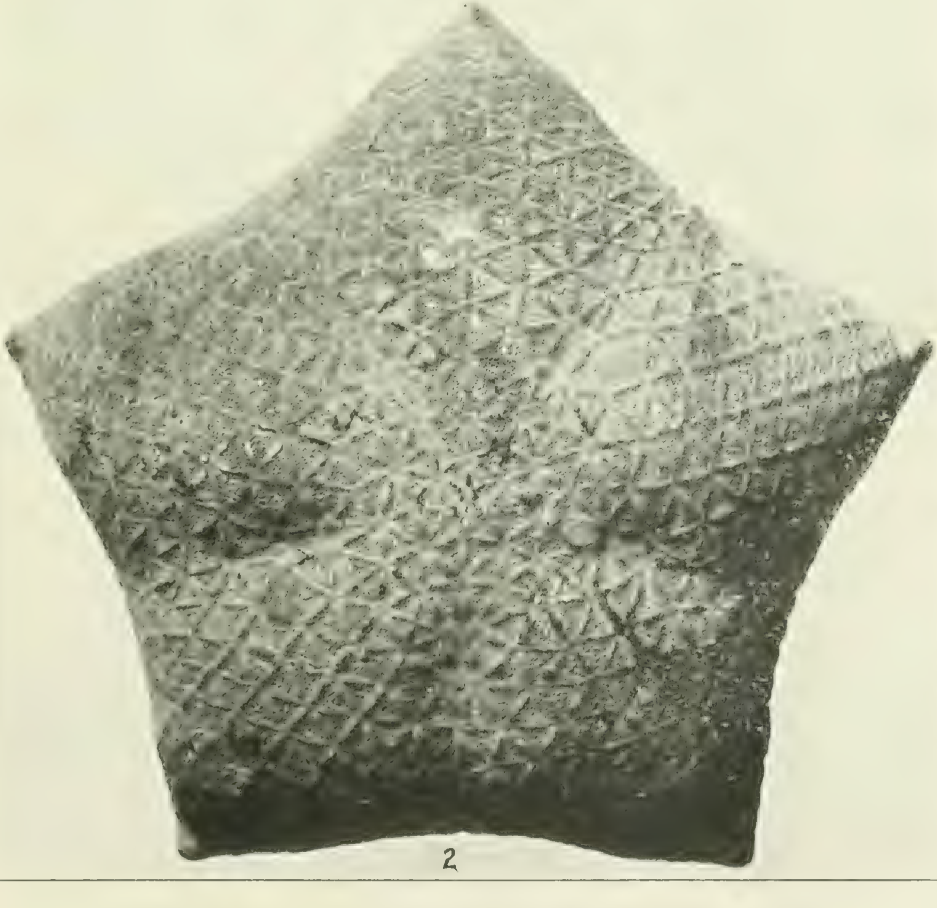
PLATE 99.

Halityle regularis, type.

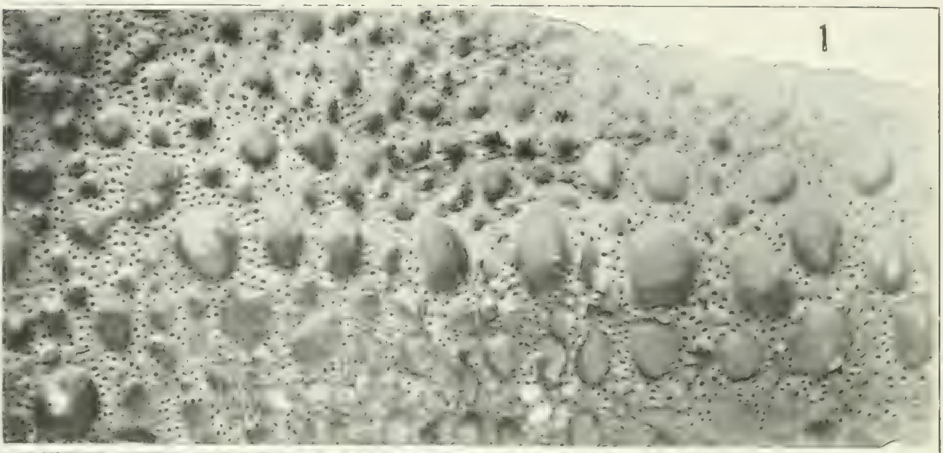
FIG. 1. Specimen photographed from side to show marginal plates, reduced, p. 362.

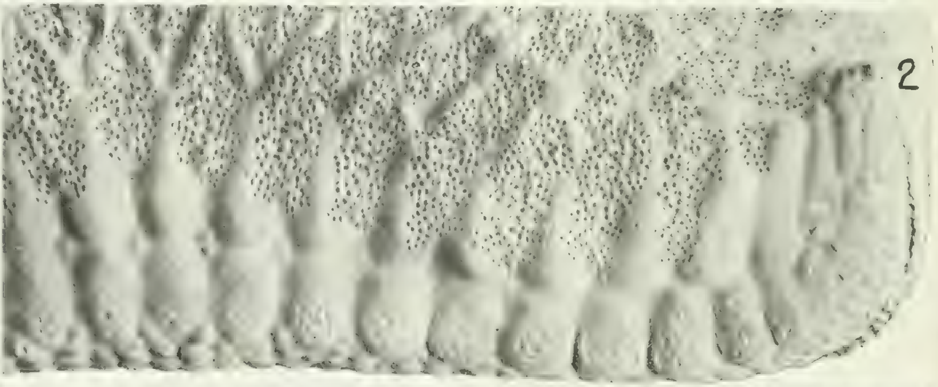
2. Abactinal view, showing the regular papular areas, reduced.

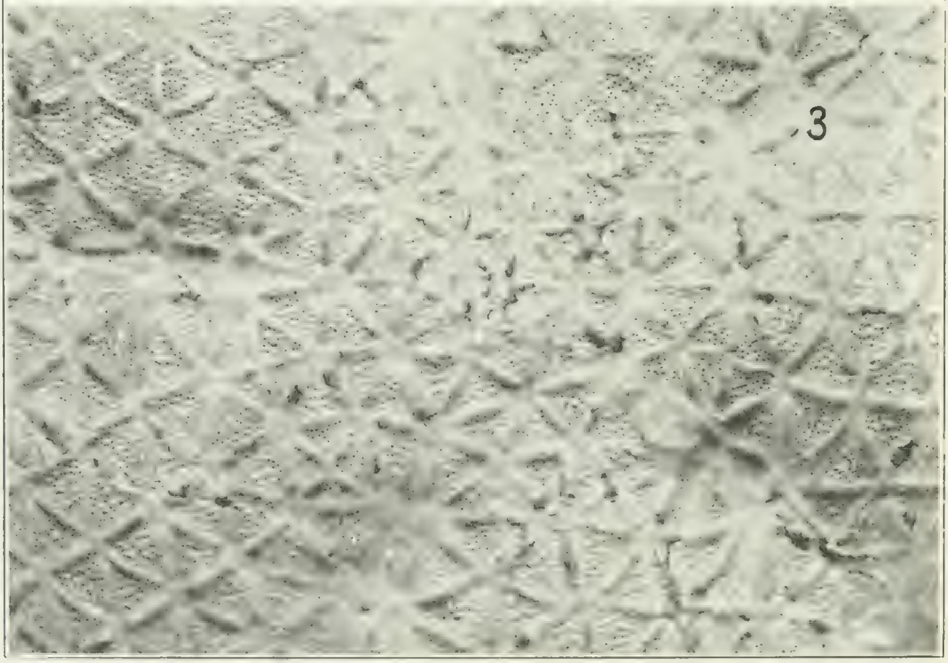

1


2

STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.


1


2


3

Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 100.

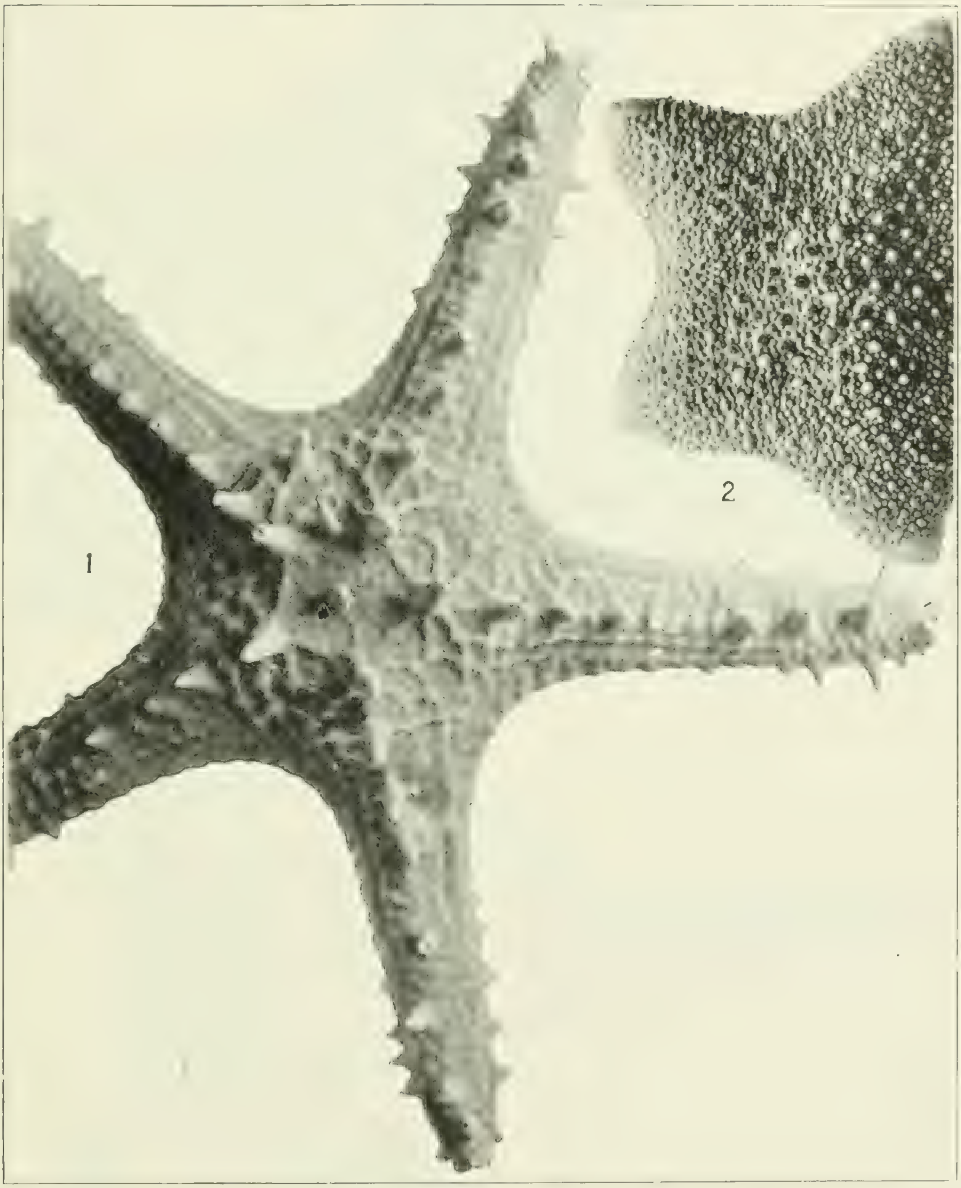
FIG. 1. *Pentaceropsis tyloderma;* portion of radial region of abactinal surface, enlarged, p. 350.

2. *Halityle regularis;* side of body showing marginal plates and end of ray, p. 362.

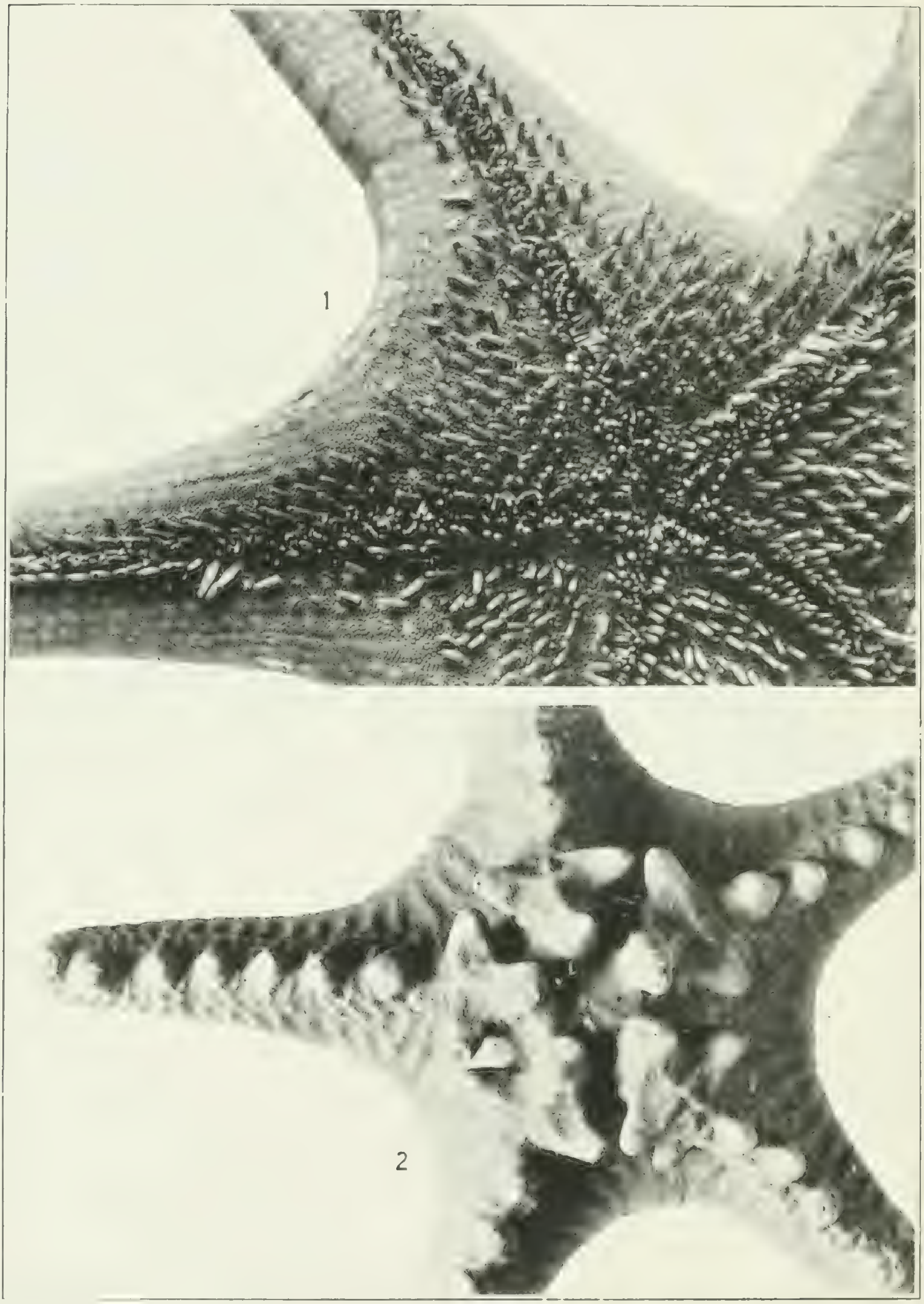
3. Same; apical area showing the regular papular areas.

PLATE 101.

FIG. 1. *Oreaster alveolatus;* abactinal view, reduced, p. 348.
2. *Asterodiscus elegans;* abactinal view, p. 355.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



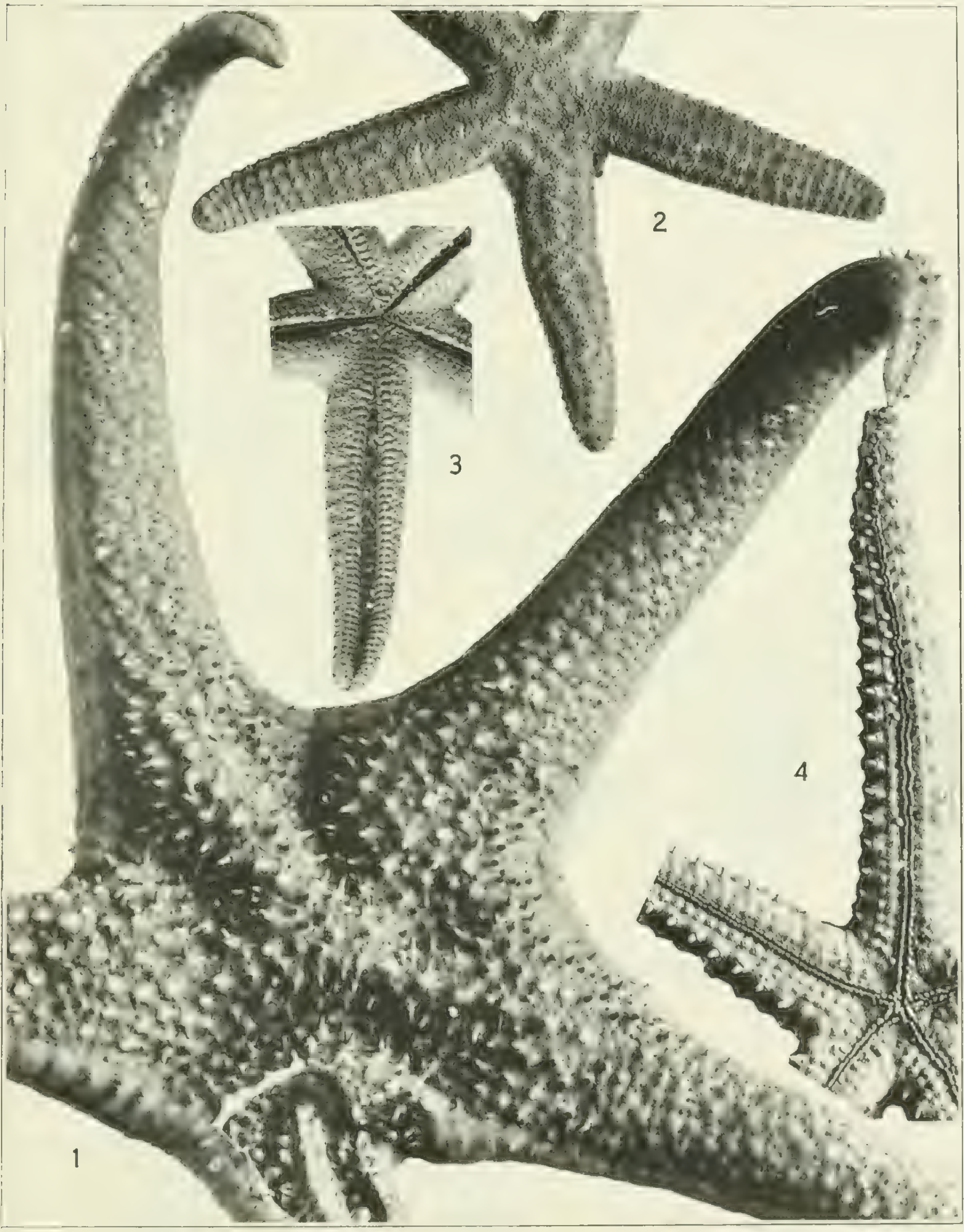
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 102.

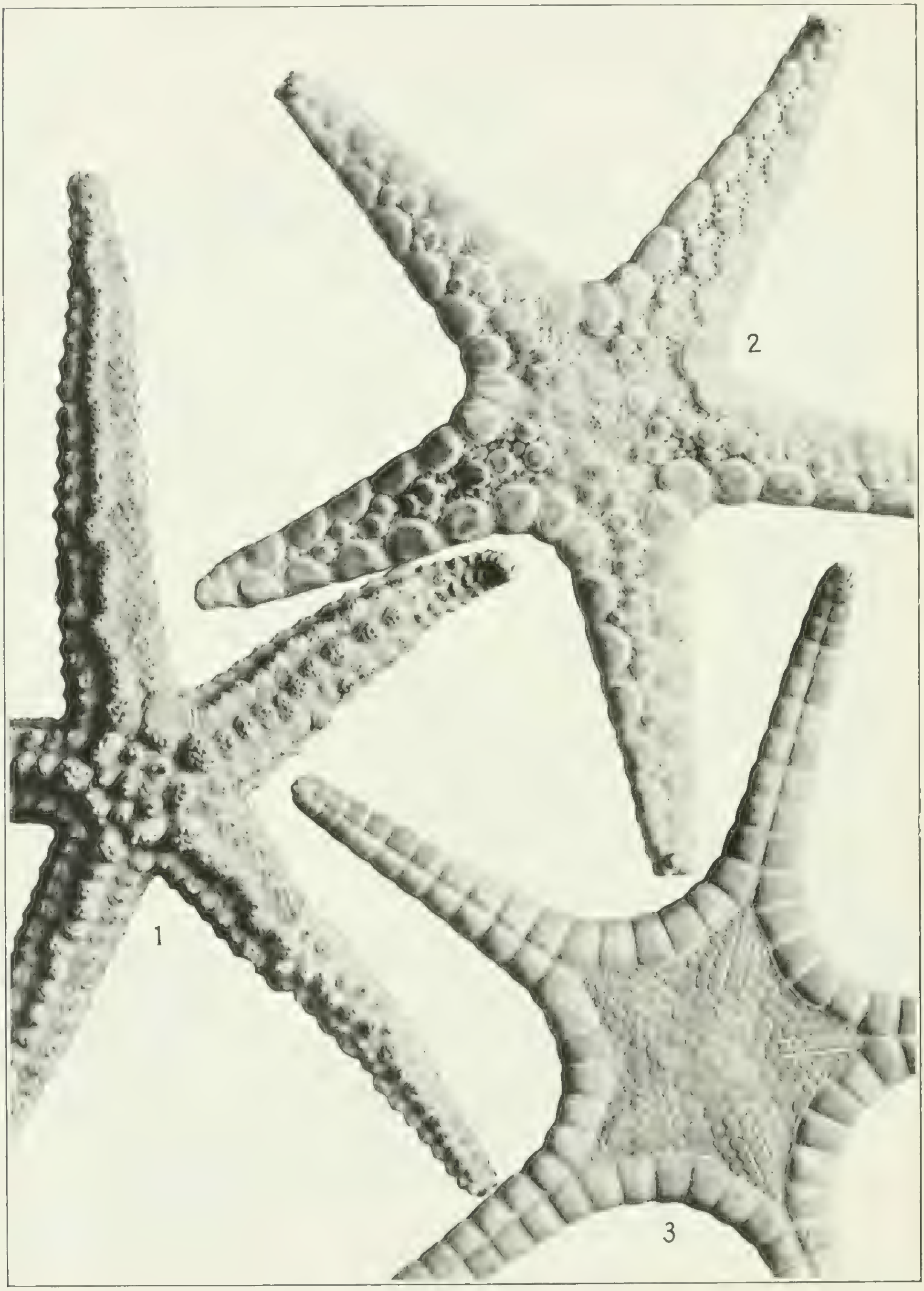
FIG. 1. *Dissogenes styracia;* portion of actinal surface of type, enlarged, p. 368.
2. *Oreaster nodosus;* abactinal surface, reduced, p. 346.

PLATE 103.

FIG. 1. *Dissogenes styracia;* abactinal aspect of type, p. 368.
2. *Ophidiaster trychnus;* abactinal view of type, enlarged, p. 390.
3. Same; actinal view of type, enlarged.
4. *Ophidiaster fuscus;* actinal aspect, p. 388.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

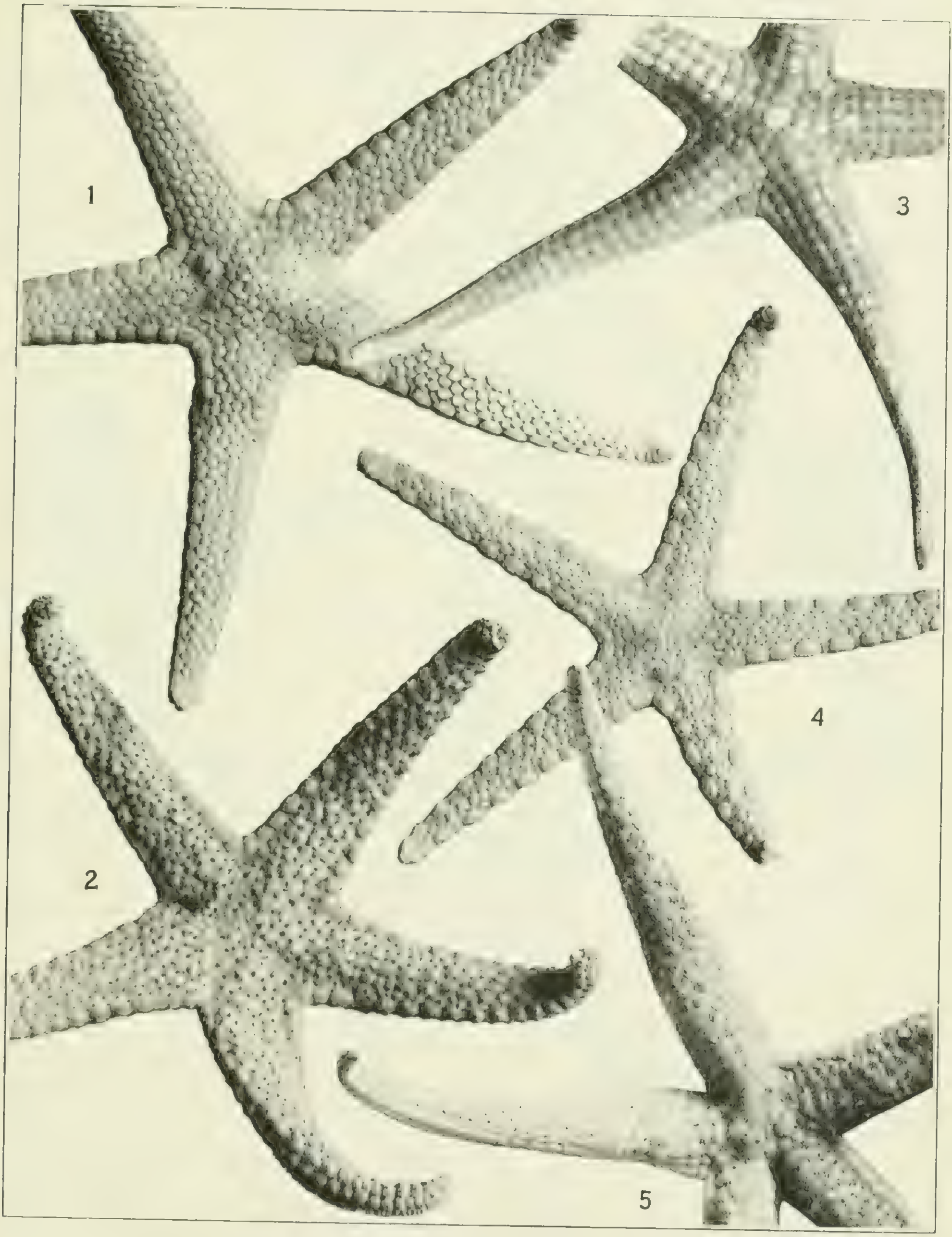
PLATE 104.

FIG. 1. *Ophidiaster fuscus;* abactinal view, enlarged, p. 388.
2. *Ferdina glyptodisca;* abactinal view, enlarged, p. 370.
3. *Iconaster longimanus;* abactinal view, enlarged, p. 303.

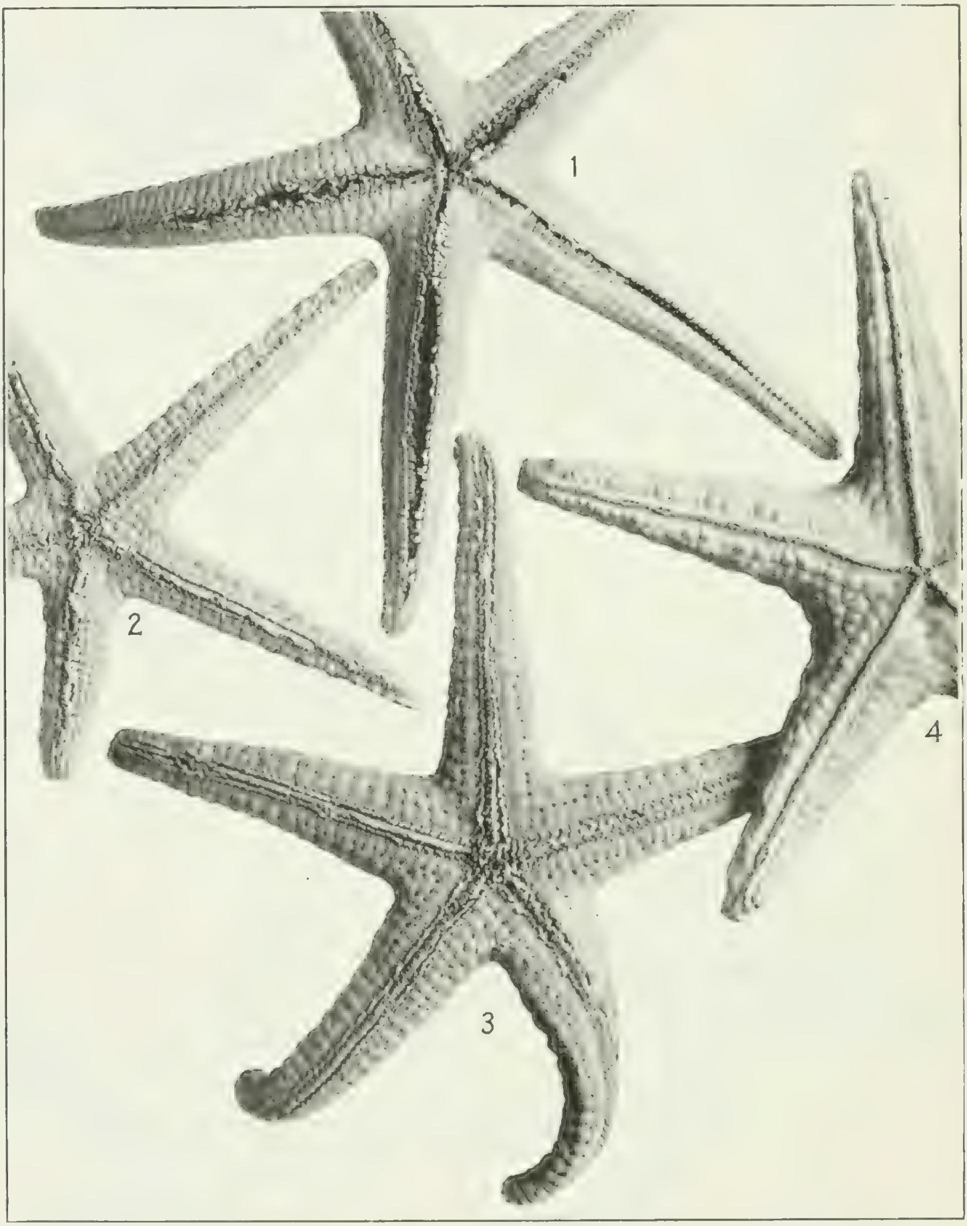
Plate 105.

Fig. 1. *Fromia eusticha*, type; abactinal view, outer part of one ray with granules removed to show plates, p. 375.

2. *Fromia hemiopla*, type; abactinal view, p. 377.
3. *Nardoa semiregularis;* abactinal aspect, p. 383.
4. *Fromia japonica;* abactinal view, p. 373.
5. *Nardoa squamulosa;* abactinal view, p. 383.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

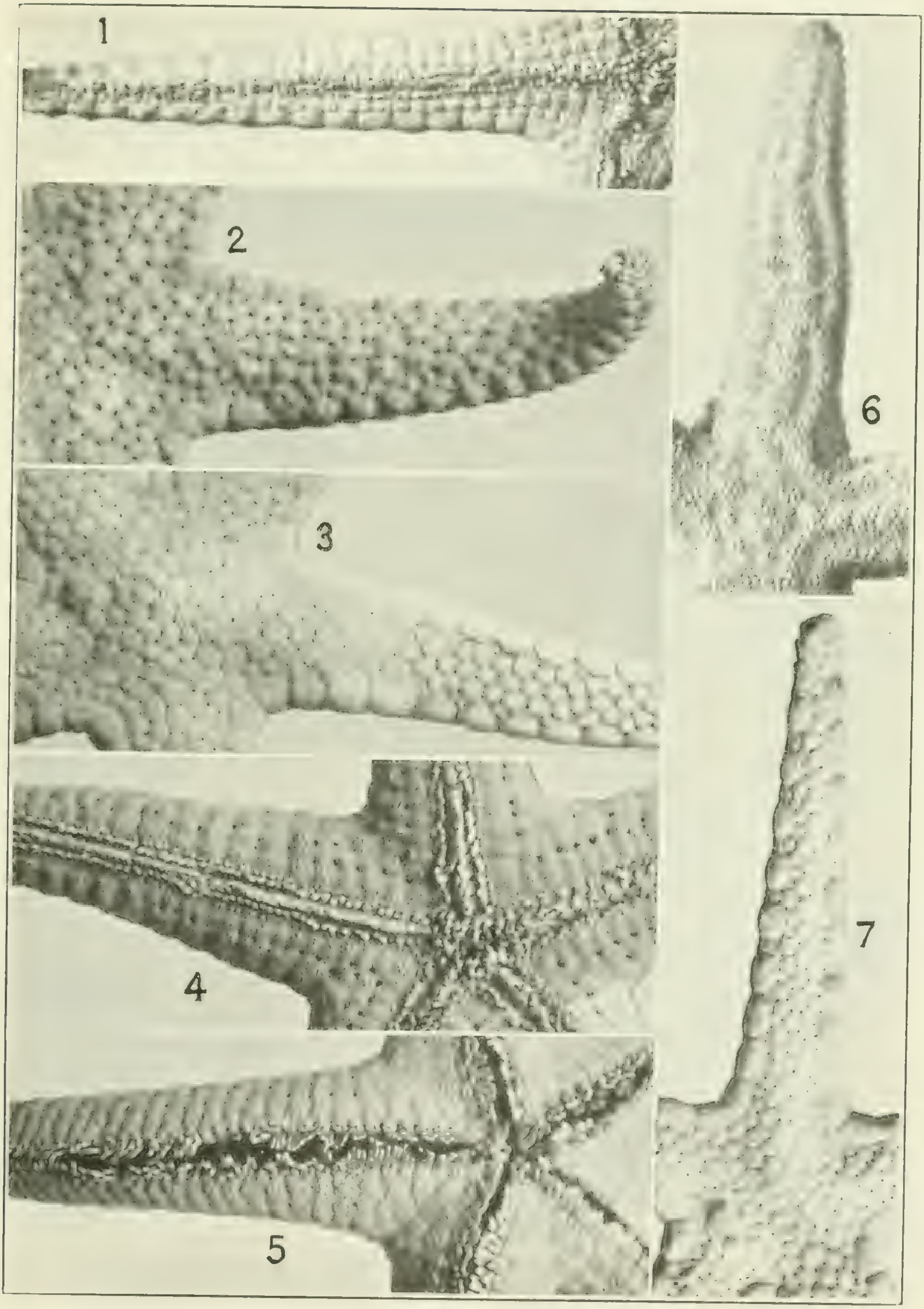
PLATE 106.

FIG. 1. *Fromia eusticha*, type; actinal surface, p. 375.
2. *Fromia japonica*, station 5251; actinal surface, p. 373.
3. *Fromia hemiopla*, type; actinal surface, p. 377.
4. *Ferdina glyptodisca*, type; actinal surface, p. 370.

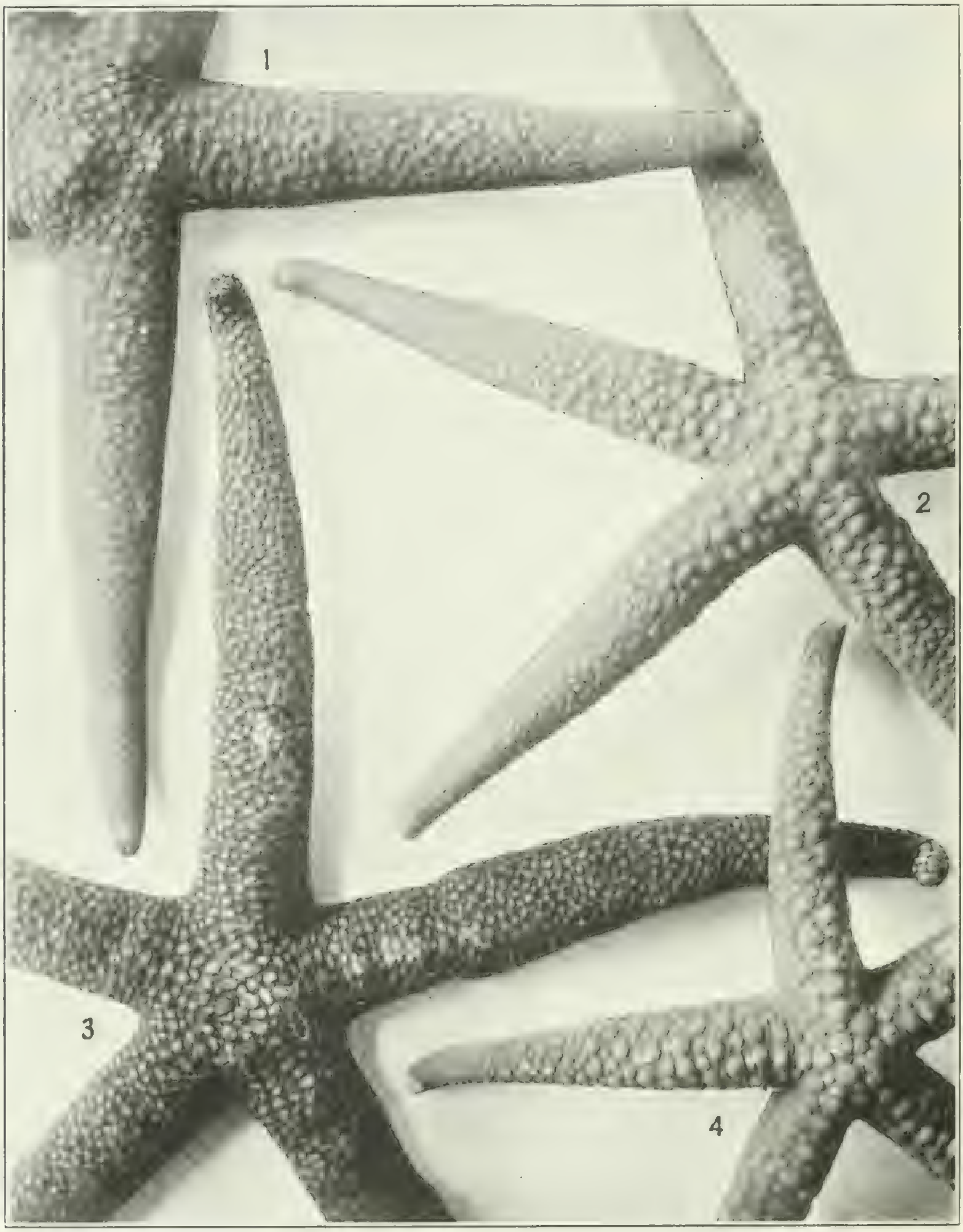
Plate 107.

Enlarged details of abactinal and actinal surfaces.

Fig. 1. *Fromia japonica;* actinal, p. 373.
2. *Fromia hemiopla;* abactinal, p. 377
3. *Fromia eusticha;* abactinal, p. 375.
4. *Fromia hemiopla;* actinal, p. 377.
5. *Fromia eusticha;* actinal, p. 375.
6. *Ophidiaster trychnus;* abactinal, p. 390.
7. *Fromia japonica;* abactinal, p. 373.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 108.

Fig. 1. *Nardoa mollis;* Mër Island (Murray Islands), Torres Strait. (M. C. Z. Coll.) P. 381.

2. *Nardoa novae-caledoniae;* Mër Island. (M. C. Z. Coll.) P. 379.

3. *Nardoa pauciforis;* No. 2322, Museum of Comparative Zoölogy, Mër (Murray Islands), Torres Strait. P. 381.

4. *Nardoa variolata,* Mauritius. (M. C. Z. Coll.) P. 379.

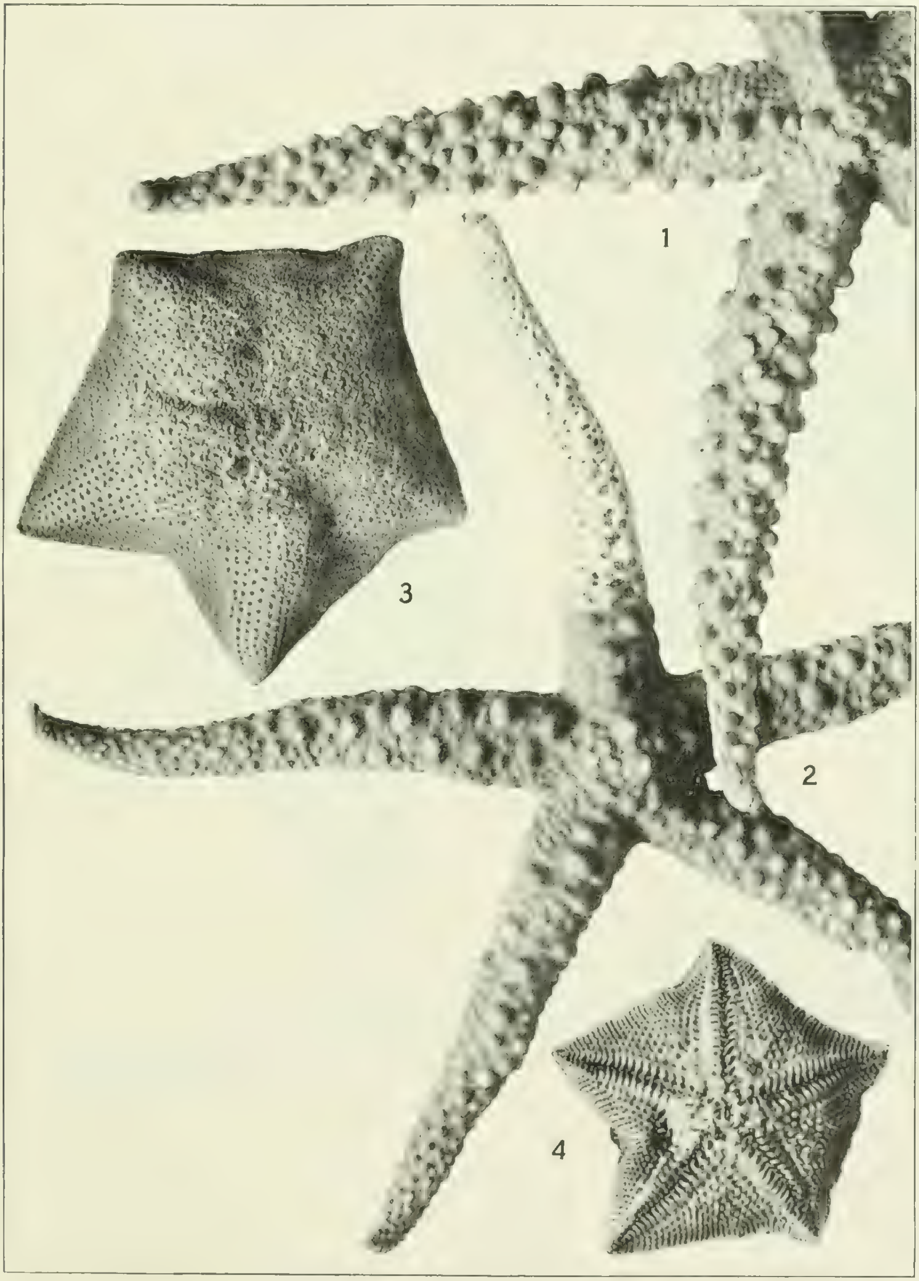
Plate 109.

Fig. 1. *Nardoa frianti;* abactinal surface, p. 385.

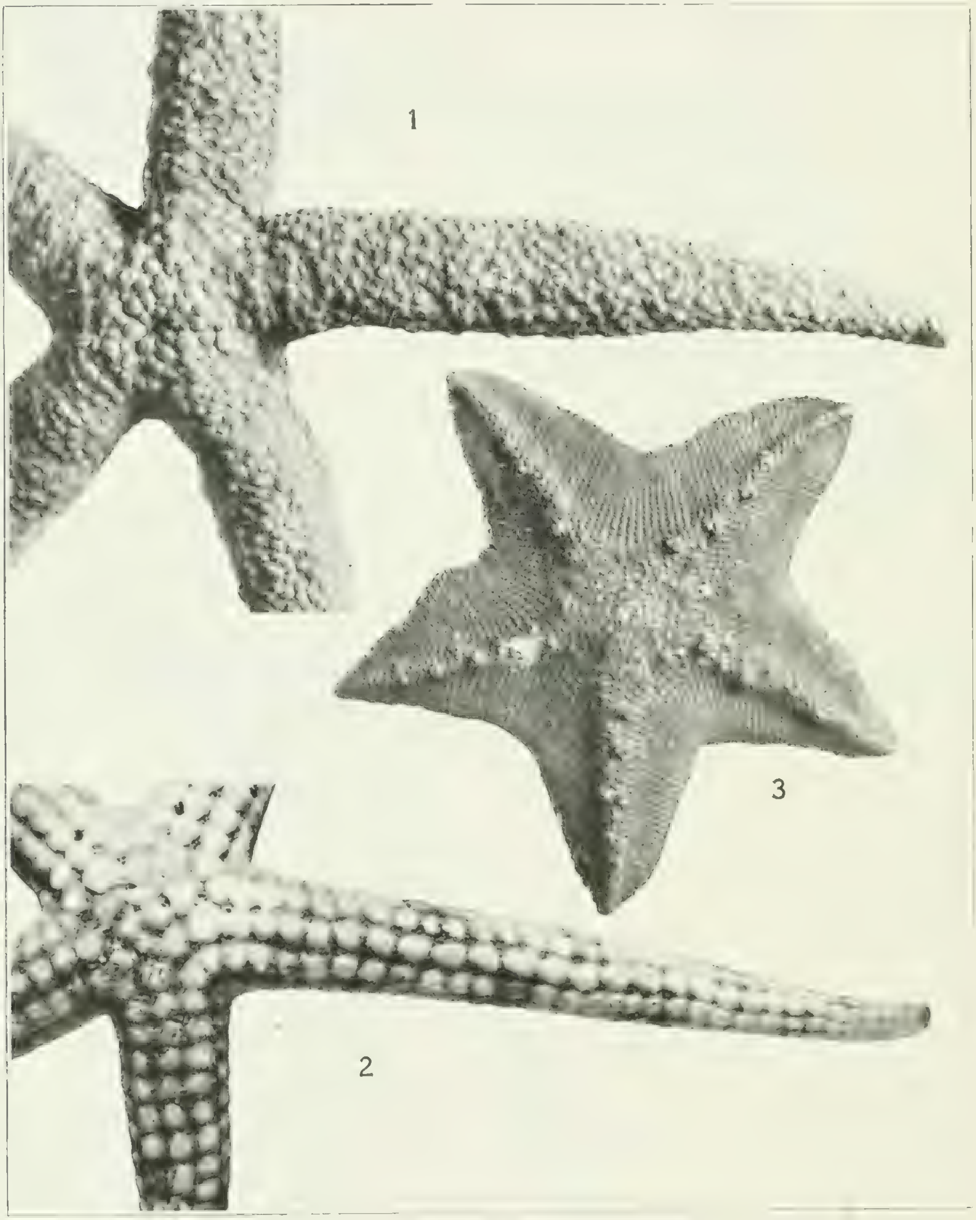
2. *Nardoa tumulosa;* abactinal surface of type, p. 386.

3. *Patiriella exigua;* abactinal surface of a specimen from Panbutan Bay, p. 416.

4. Same; actinal surface of same specimen, enlarged.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

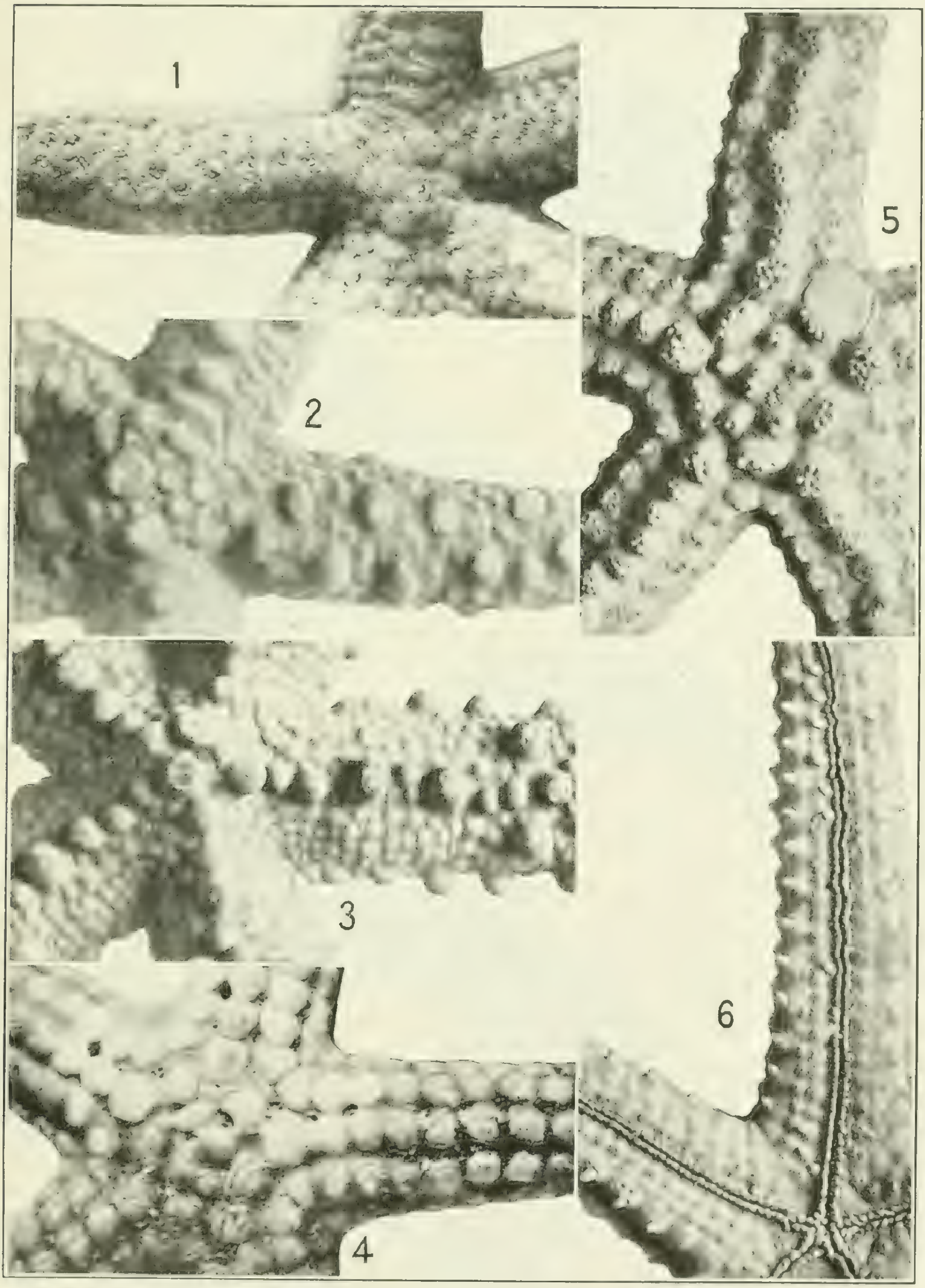
Plate 110.

Fig. 1. *Nardoa tuberculata;* abactinal surface; p. 384.
2. *Ophidiaster dubiosus;* abactinal surface, enlarged, p. 394.
3. *Anseropoda macropora;* abactinal surface of type, enlarged, p. 424.

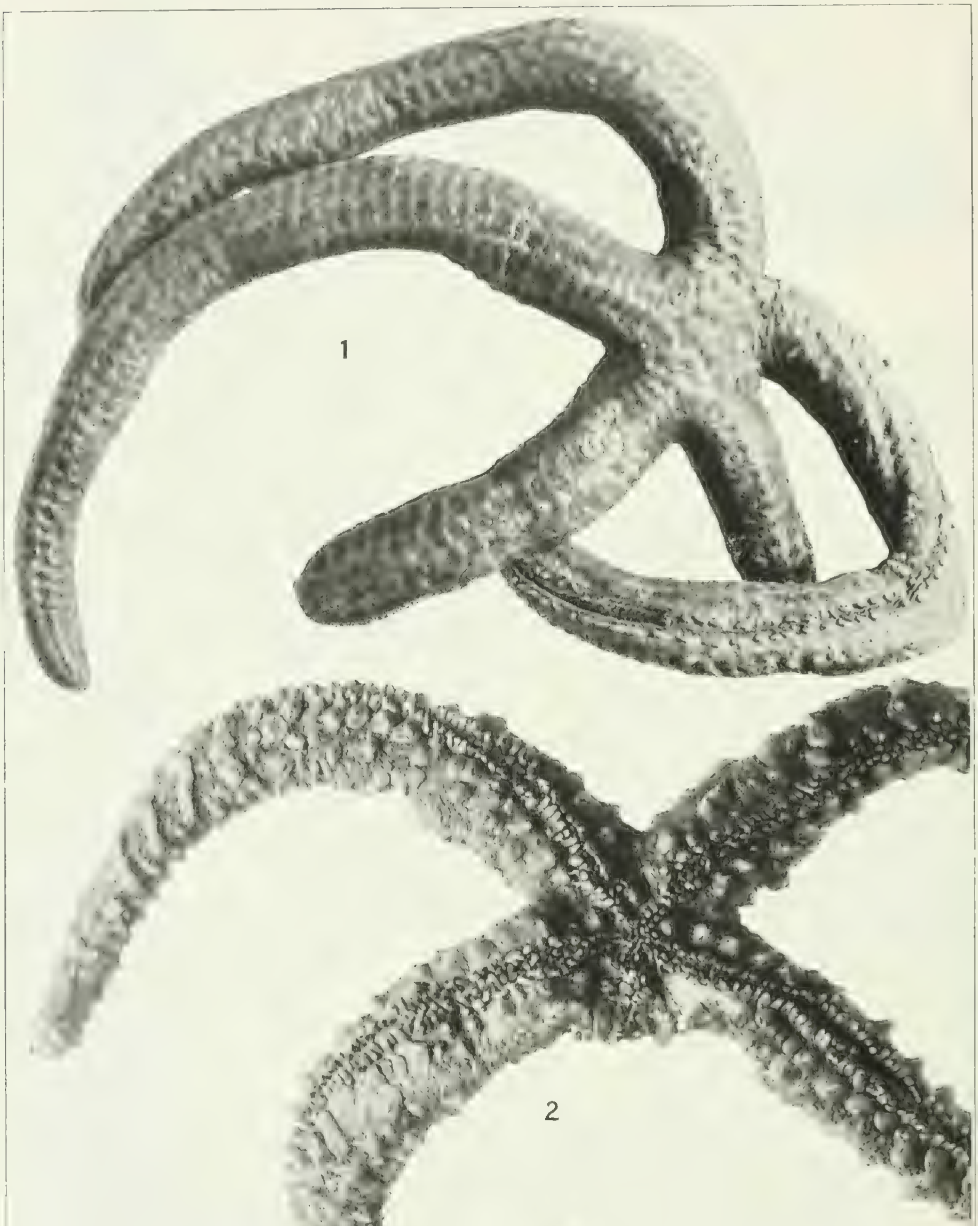
PLATE 111.

Enlarged details of abactinal and actinal surfaces.

FIG. 1. *Nardoa squamulosa;* abactinal, p. 383.
2. *Nardoa tumulosa;* abactinal, p. 386.
3. *Nardoa frianti;* abactinal, p. 385.
4. *Ophidiaster dubiosus;* abactinal, p. 394.
5. *Ophidiaster fuscus;* abactinal, p. 388.
6. Same; actinal.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 112.

FIG. 1. *Leiaster analogus*, type; abactinal aspect, showing also the side and actinal surface, p. 396.

2. *Echinaster callosus;* actinal aspect, showing also the side of 2 rays, p. 428.

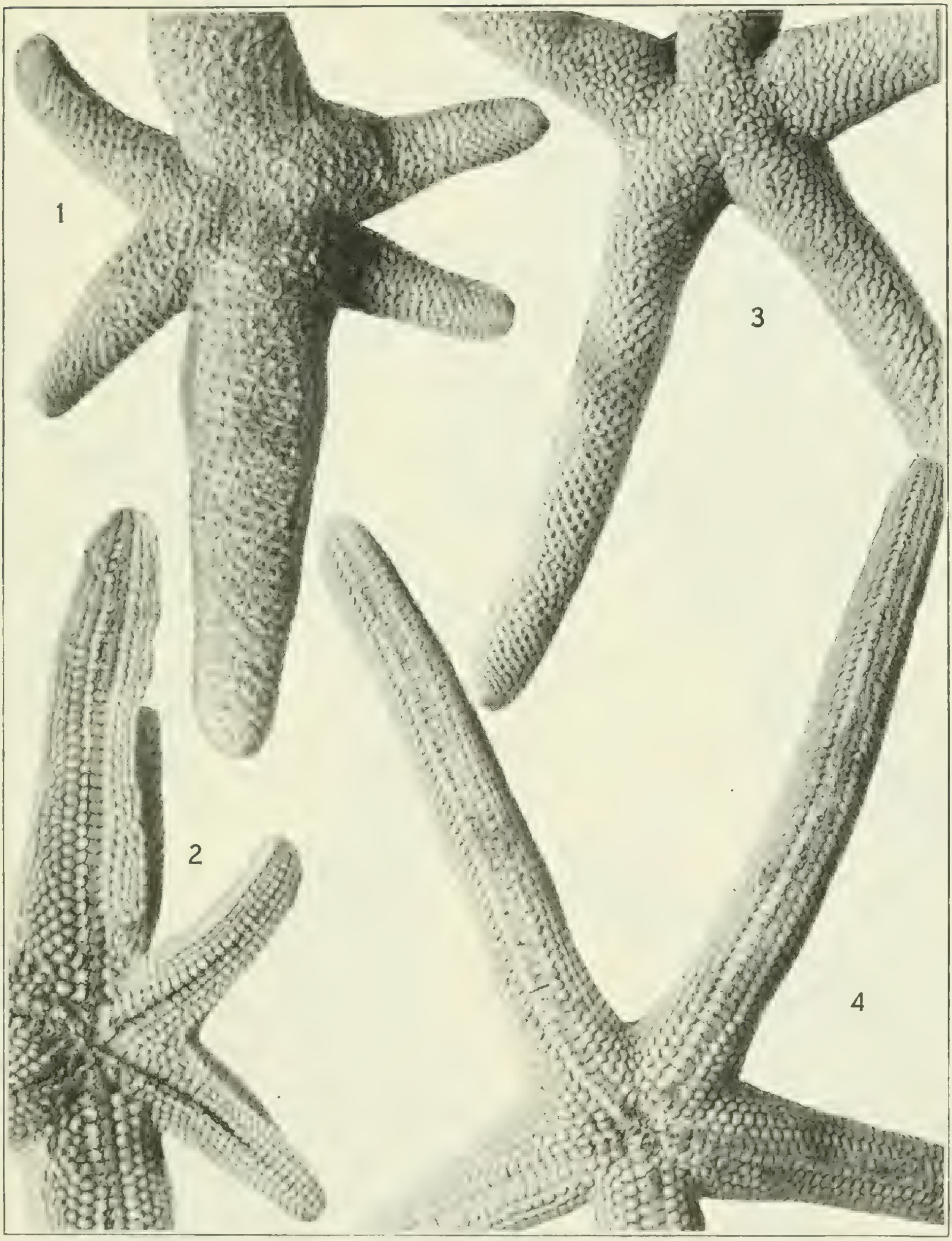
Plate 113.

Fig. 1. *Nepanthia joubini;* abactinal surface, enlarged, p. 423.

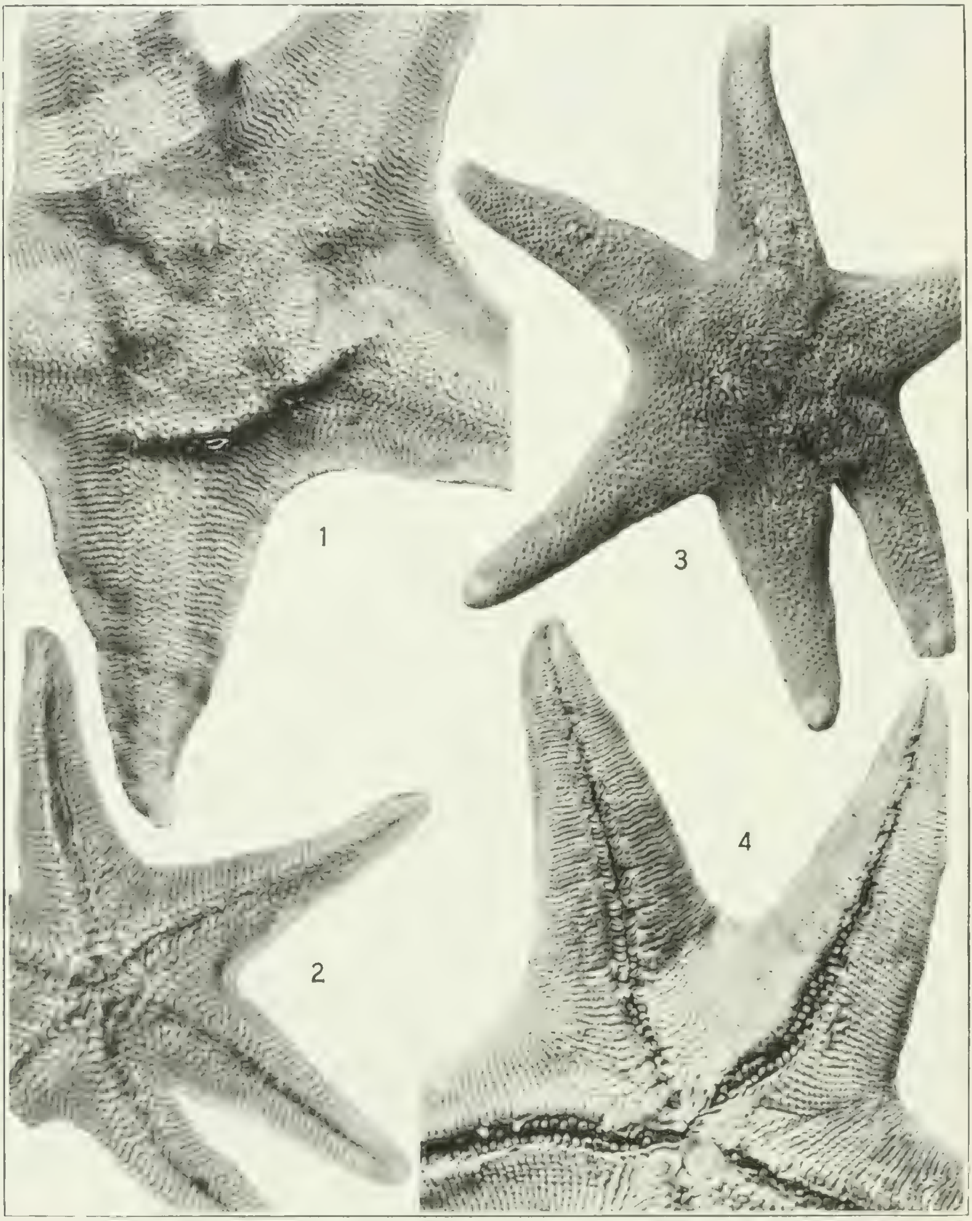
2. Same; actinal surface, enlarged.

3. *Nepanthia maculata;* abactinal surface, enlarged, p. 422.

4. Same; actinal view, enlarged.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 114.

FIG. 1. *Paranepanthia platydisca;* abactinal surface of type. The spinelets have been removed from an area of one ray, p. 420.

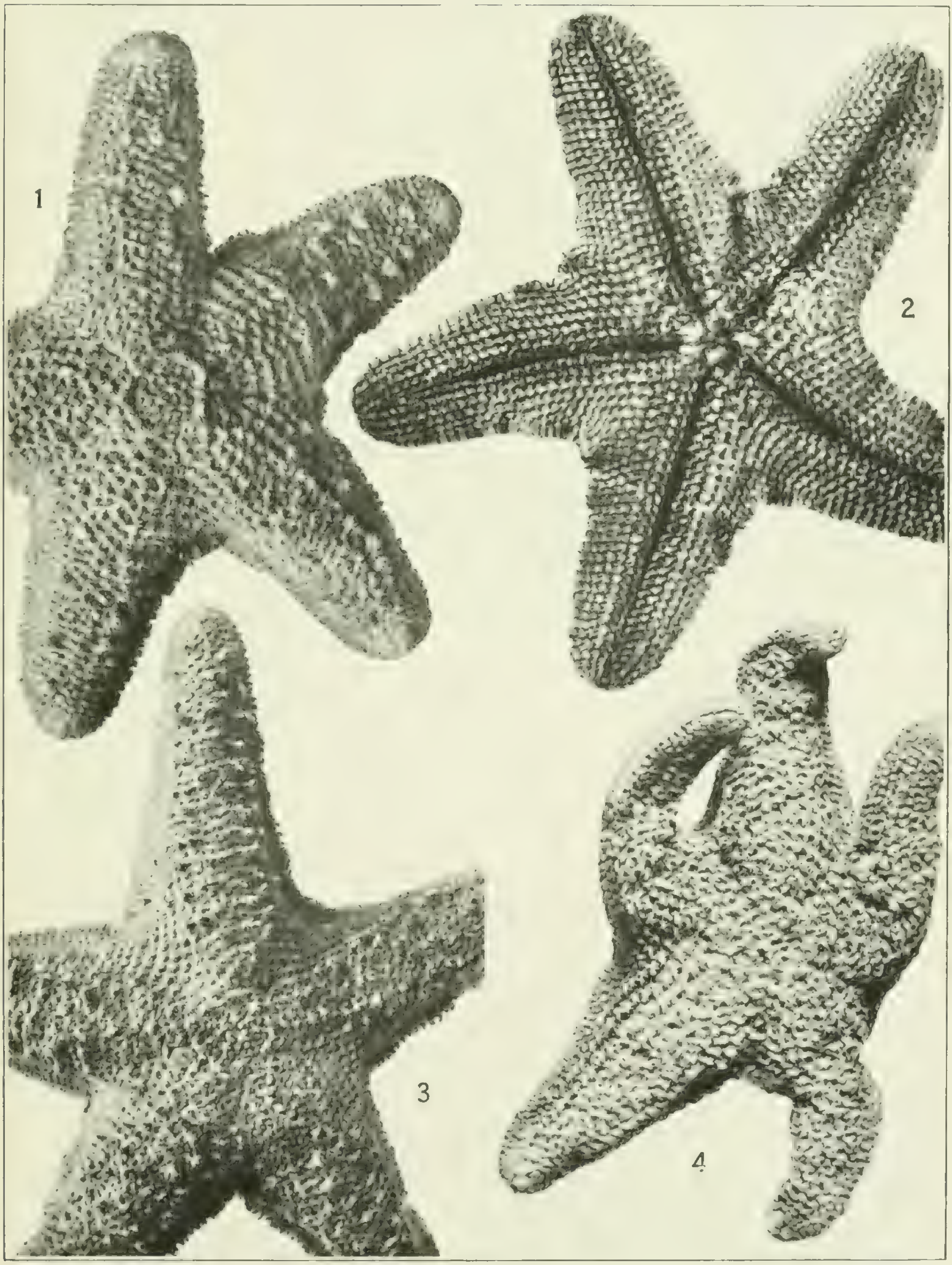
2. *Asterinopsis pedicellaris;* actinal view of type, p. 417.

3. Same; abactinal view of type.

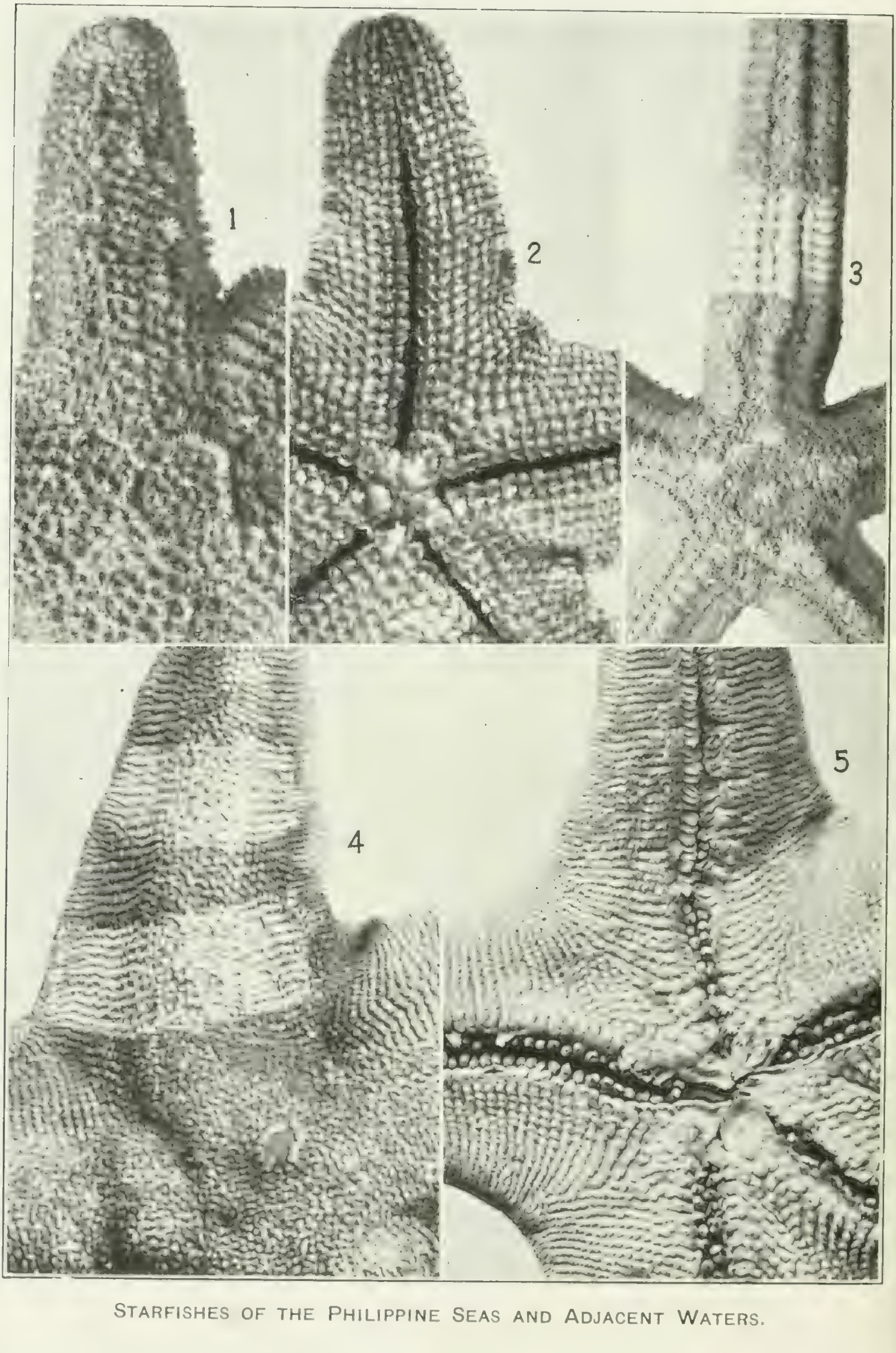
4. *Paranepanthia platydisca;* actinal aspect of the type, p. 420.

PLATE 115.

FIG. 1. *Asterina coronata euerces;* abactinal aspect of type, enlarged, p. 414.
2. Same; actinal view of type, enlarged.
3. *Asterina coronata cristata;* abactinal view of type, p. 411.
4. *Asterina cepheus;* abactinal view, enlarged, p. 411.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 116.

Enlarged details.

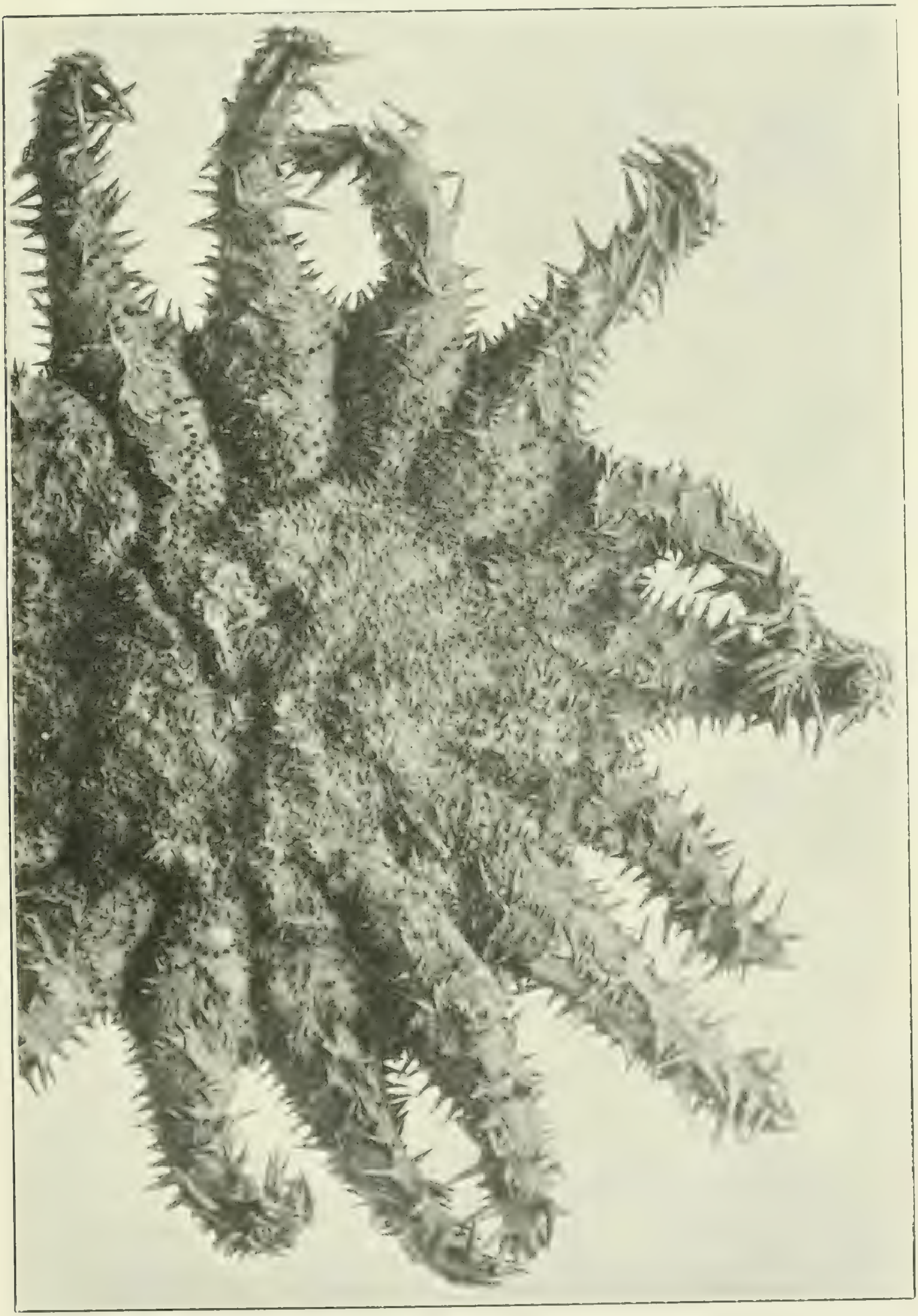
FIGS. 1, 2. *Asterina coronata cucrees;* type, p. 414.

3. *Zoroaster carinatus philippinensis;* spines cleaned from a portion of ray, p. 477.

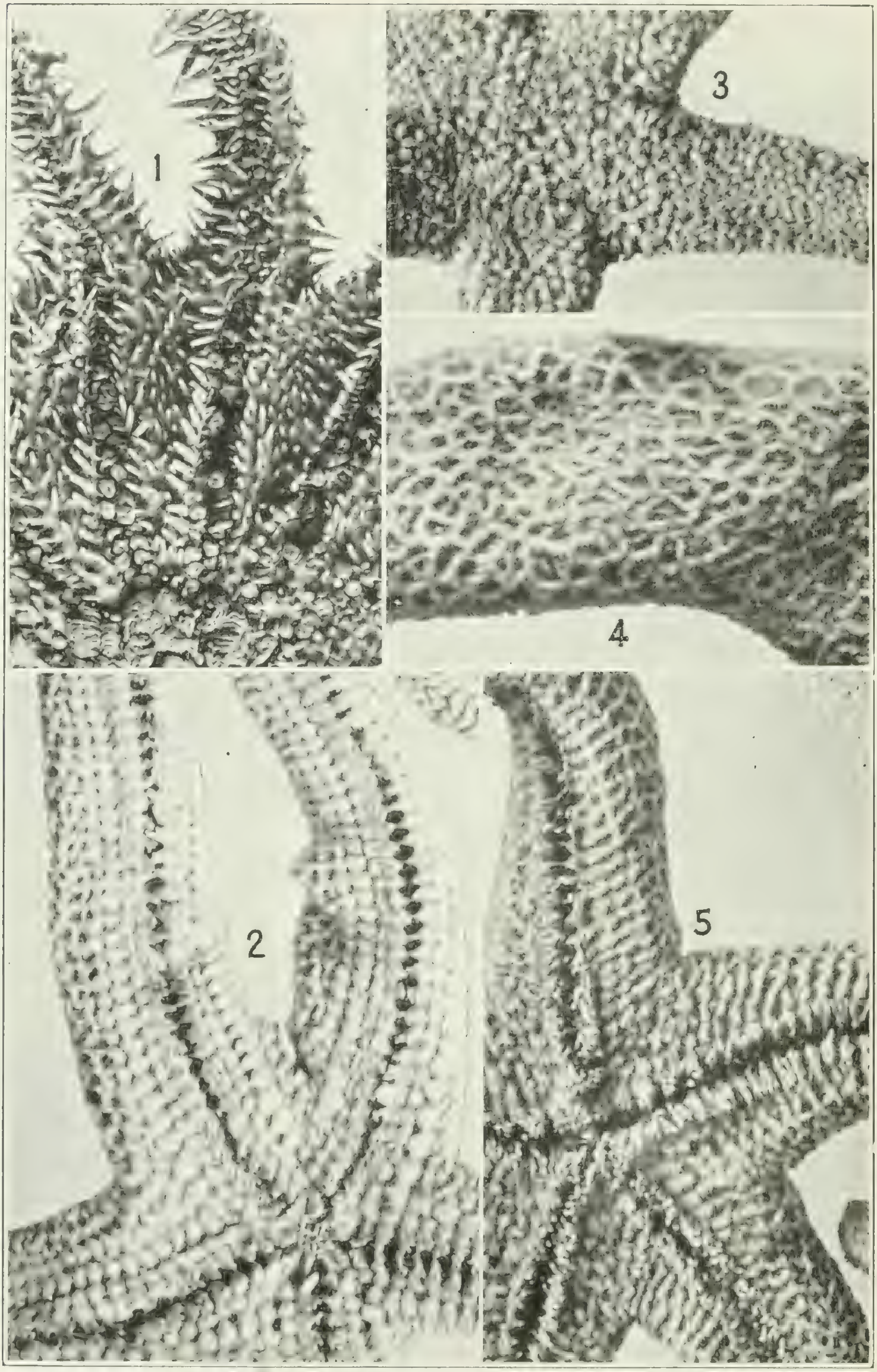
4, 5. *Paranepanthia platydisca;* type, p. 420.

PLATE 117.

Acanthaster brevispinus; abactinal view of type, p. 442.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 118.

Fig. 1. *Acanthaster brevispinus;* portion of actinal surface, p. 442.
2, 3. *Henricia densispina;* enlarged, p. 436.
4. *Henricia arcystata;* portion of ray much enlarged, p. 439.
5. *Henricia arcystata;* actinal view, enlarged.

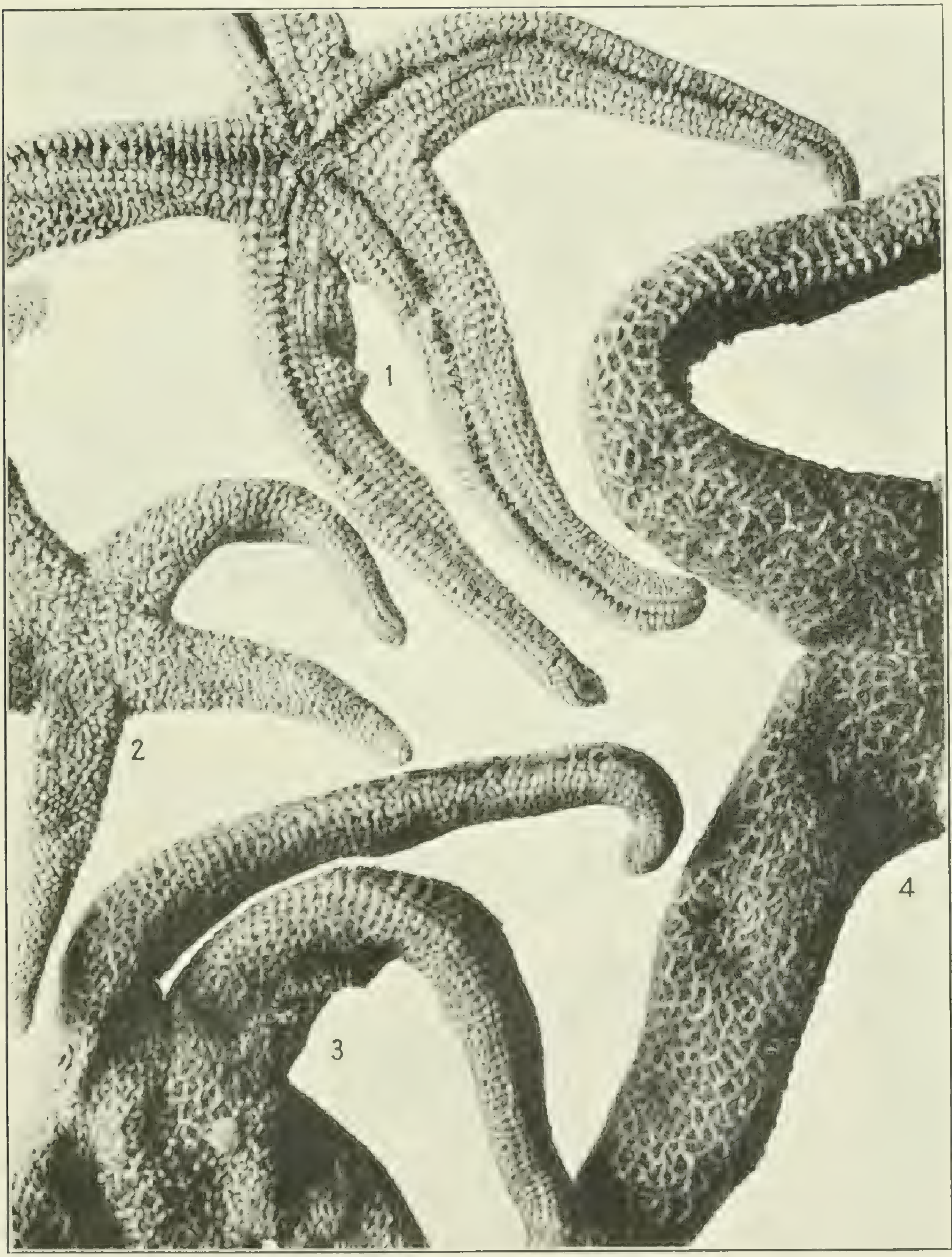
PLATE 119.

FIG. 1. *Henricia densispina;* actinal surface of specimen from station 5523, p. 436.

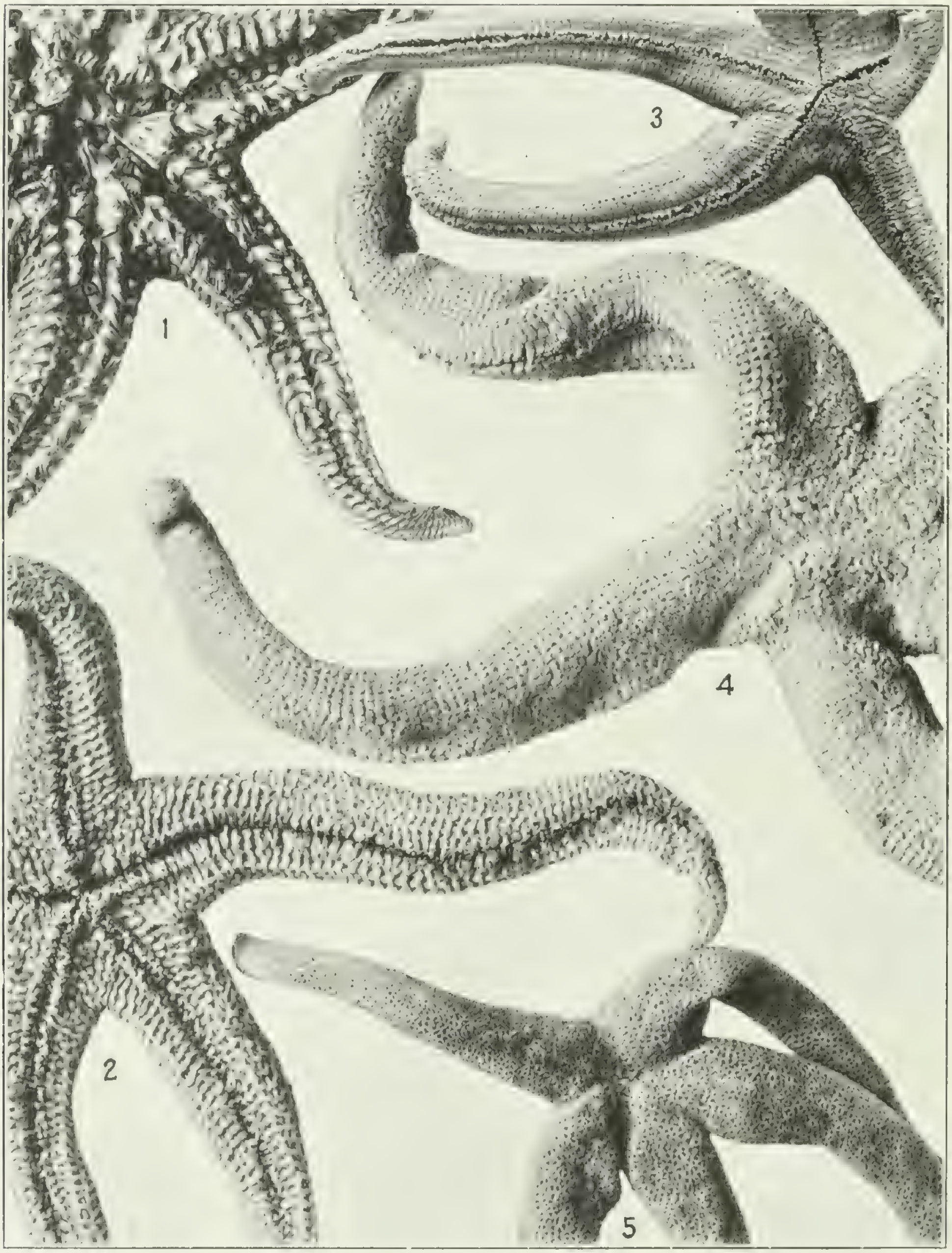
2. Same; abactinal view of another specimen from station 5523.

3. Same; abactinal view of specimen from station 5519, enlarged.

4. *Henricia arcystata;* portion of abactinal and lateral aspects of 2 rays of type, enlarged, p. 439.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



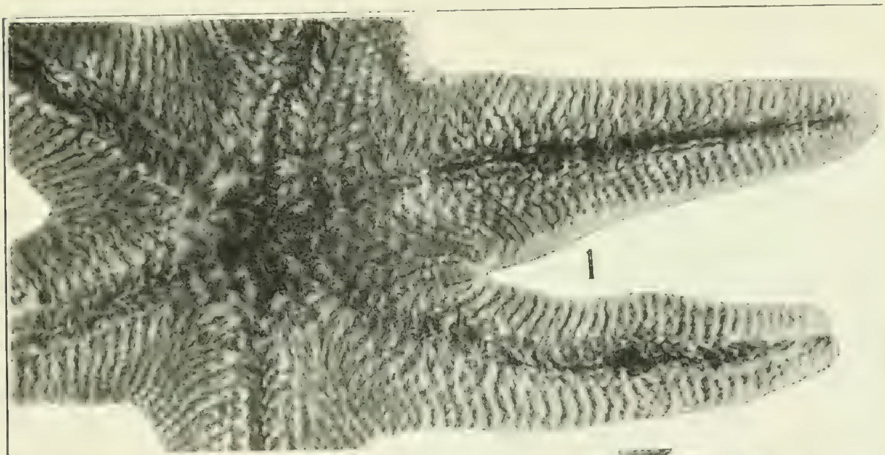
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 120.

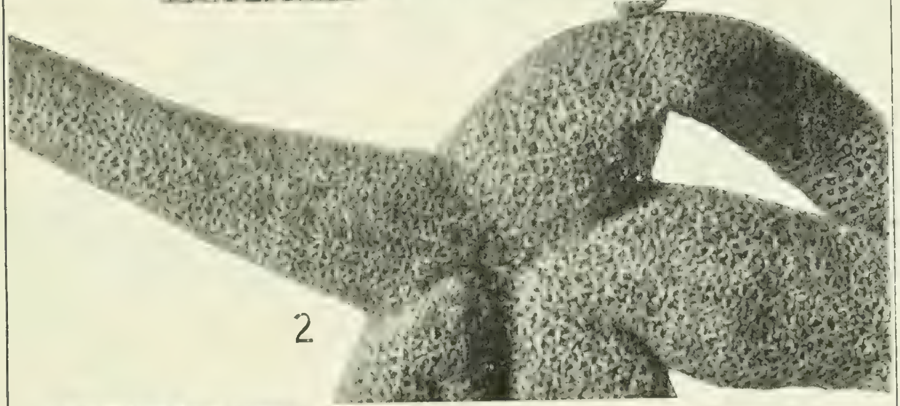
Fig. 1. *Xenorias polyctenius;* actinal view of type, p. 451.
2. *Henricia arcystata;* actinal view of type, p. 439.
3. *Henricia microplax;* actinal aspect of type, p. 437.
4. *Tarachaster tenuis;* abactinal view of type, p. 402.
5. *Henricia microplax;* abactinal view of type, p. 437.

PLATE 121.

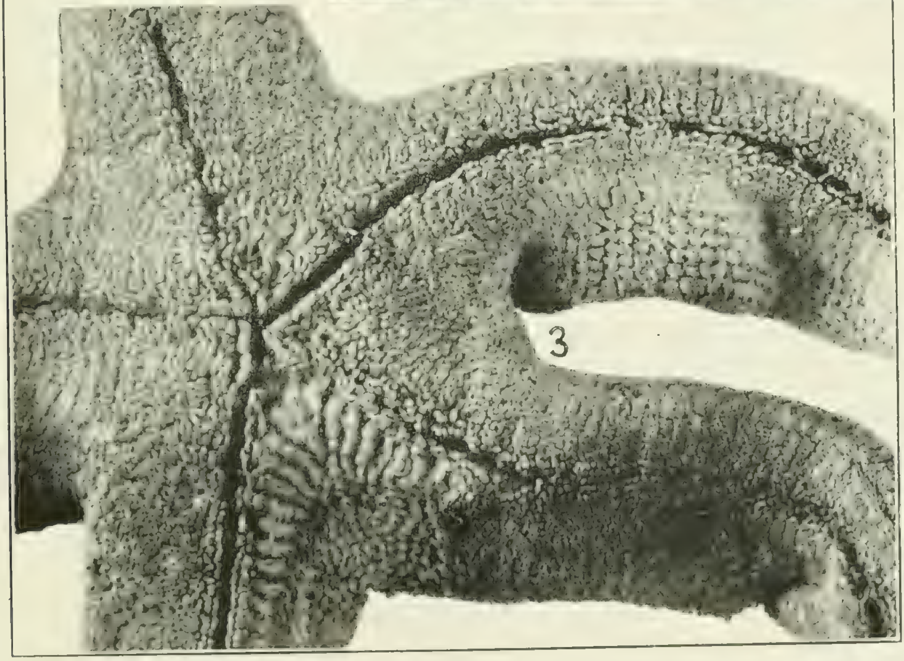
FIG. 1. *Asterinopsis pedicellaris;* type, actinal view, enlarged, p. 417.
2. *Henricia microplax;* type, abactinal view, enlarged, p. 437.
3. *Tarachaster tenuis;* type, actinal view, enlarged, p. 402.



1

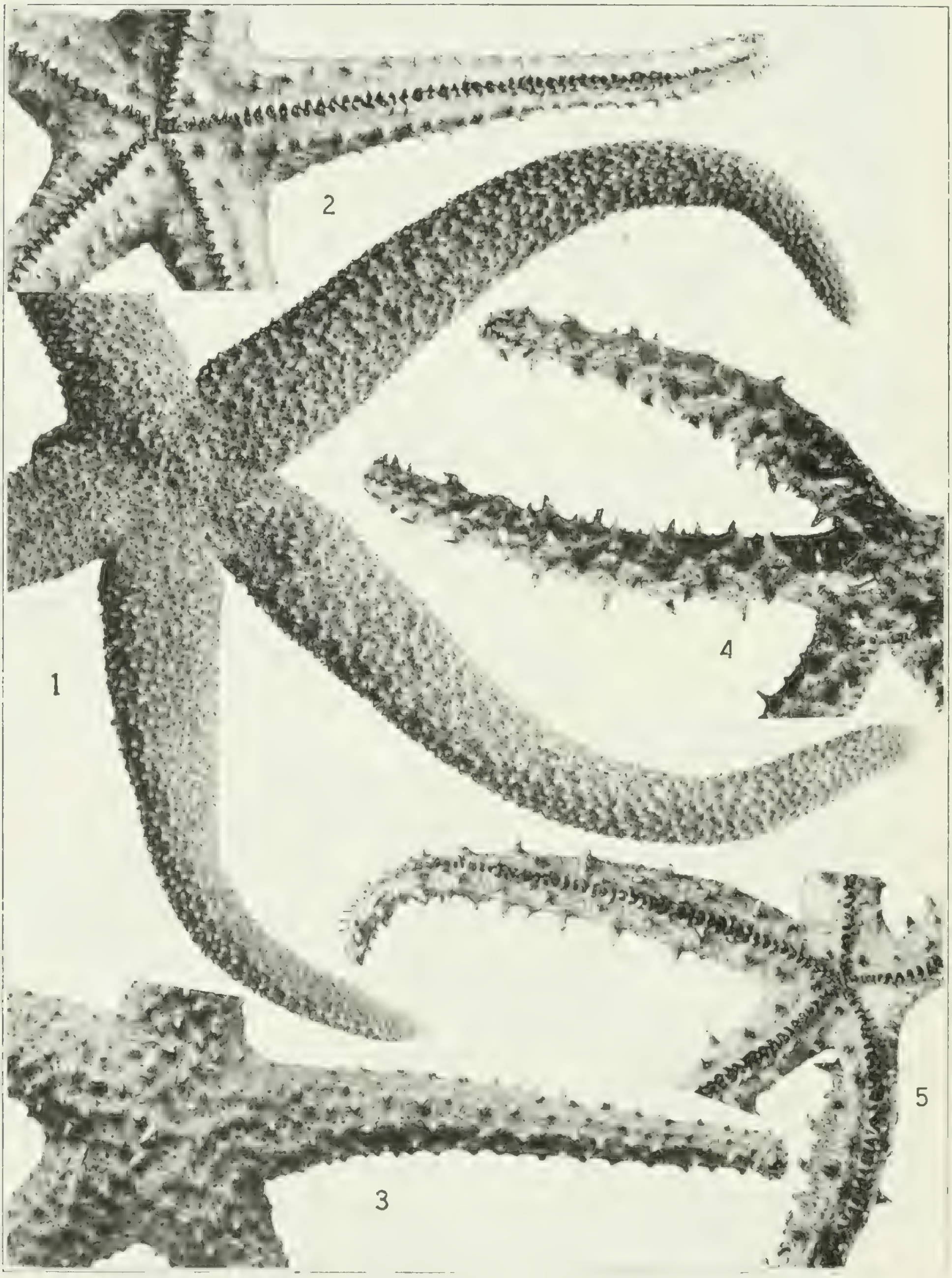


2



3

Starfishes of the Philippine Seas and Adjacent Waters.



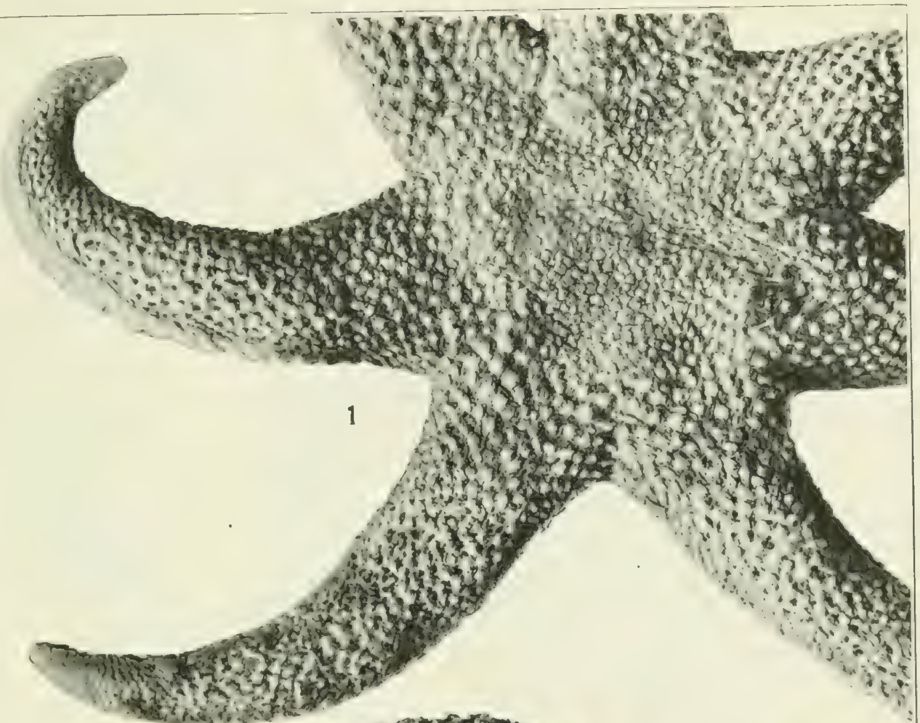
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 122.

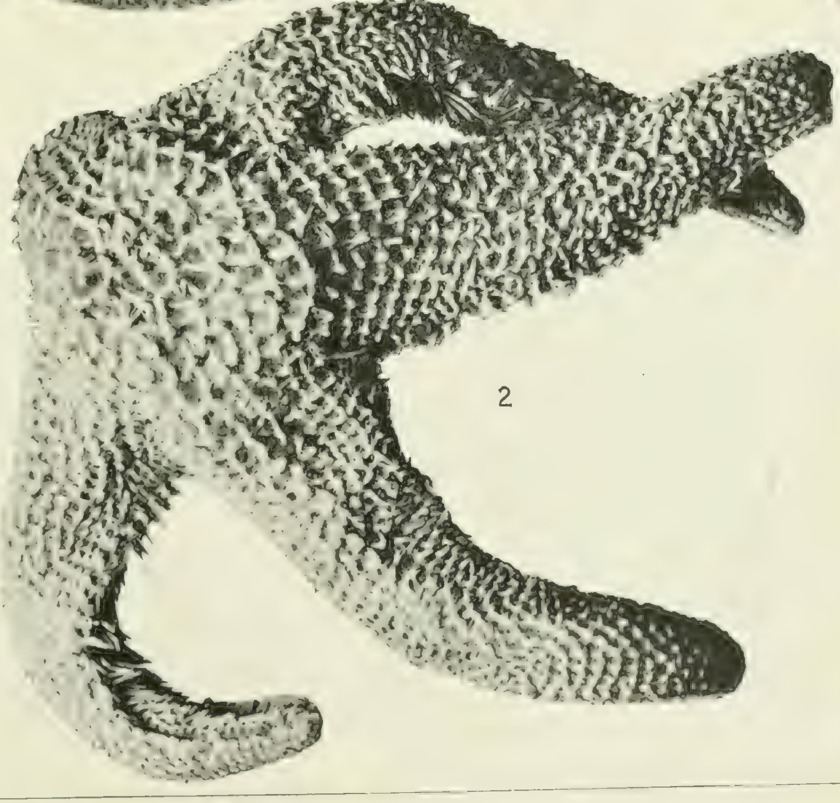
FIG. 1. *Othilia purpurea;* abactinal view, p. 432.
2. *Echinaster stereosomus;* actinal surface of type, p. 430.
3. Same; abactinal surface of type.
4. *Echinaster callosus;* abactinal surface of young specimen, p. 428.
5. Same; actinal surface.

PLATE 123.

FIG. 1. *Xenorias polyctenius;* abactinal view of type, enlarged, p. 451.
2. *Lophaster suluensis;* abactinal view of type, enlarged, p. 449.

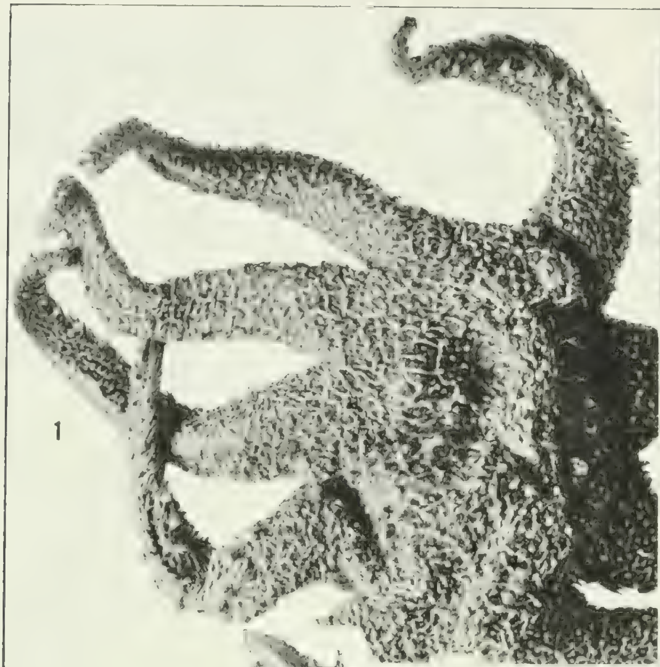


1

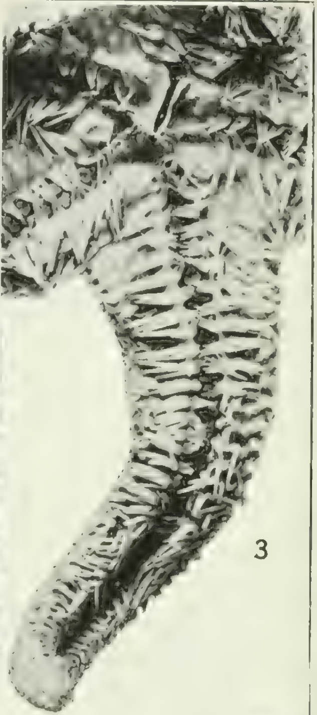


2

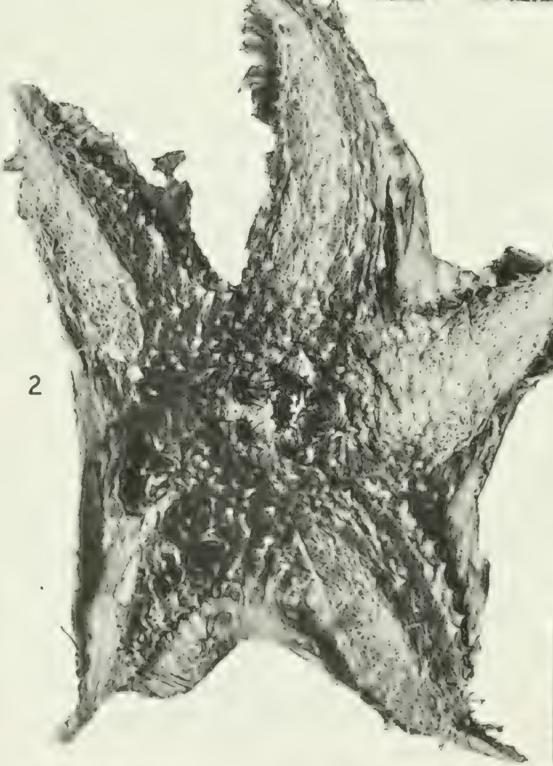
Starfishes of the Philippine Seas and Adjacent Waters



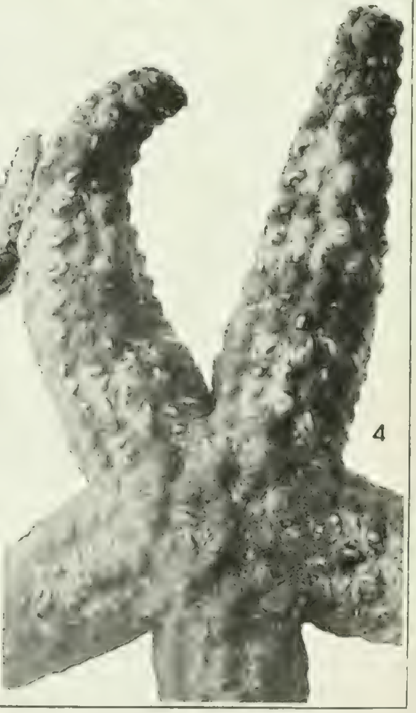
1



3



2



4

Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 124.

FIG. 1. *Crossaster scotophilus;* abactinal view of type, partly dry, enlarged, p. 447.

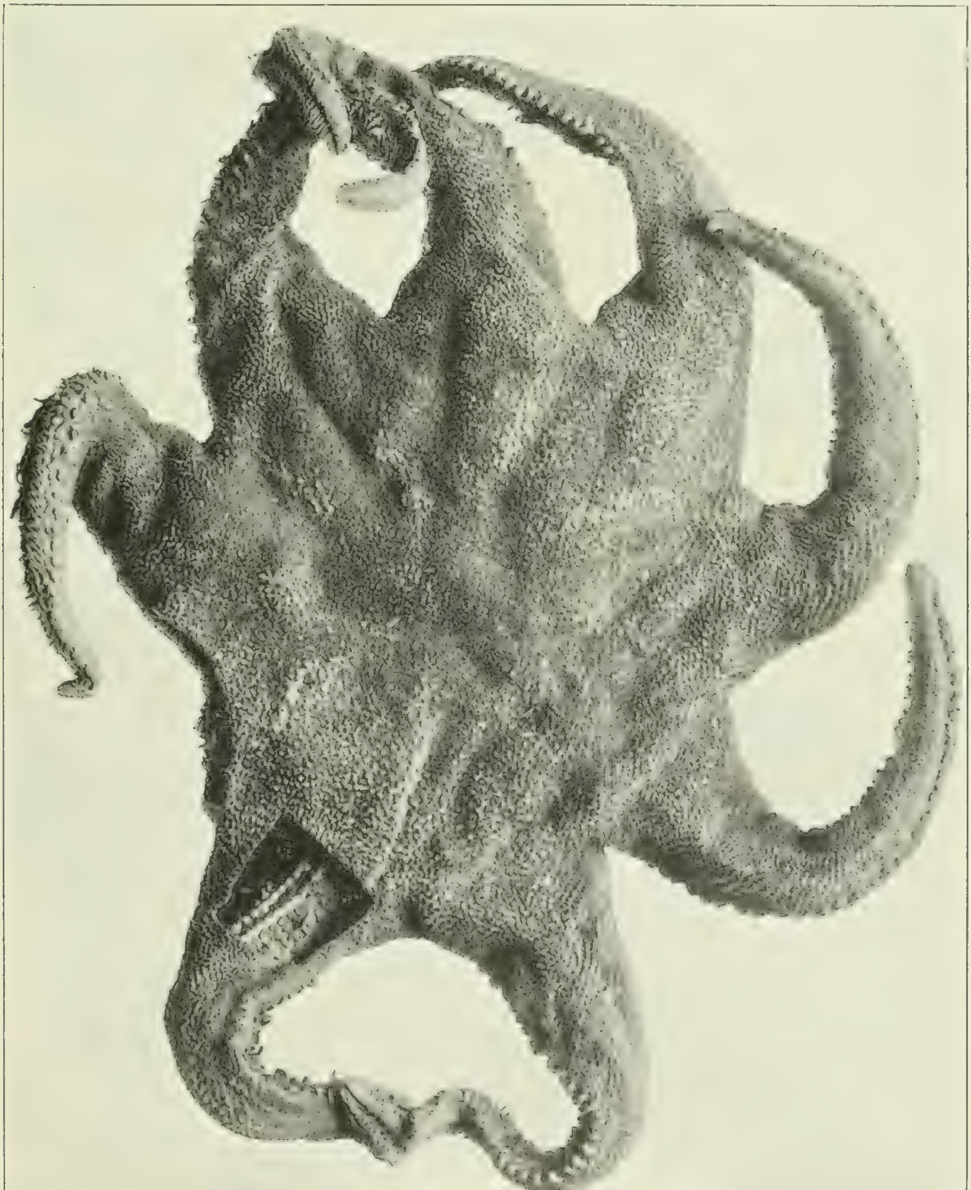
2. *Hymenaster bartschi;* abactinal view of type, p. 465.

3. *Lophaster suluensis;* actinal surface of type, enlarged, p. 449.

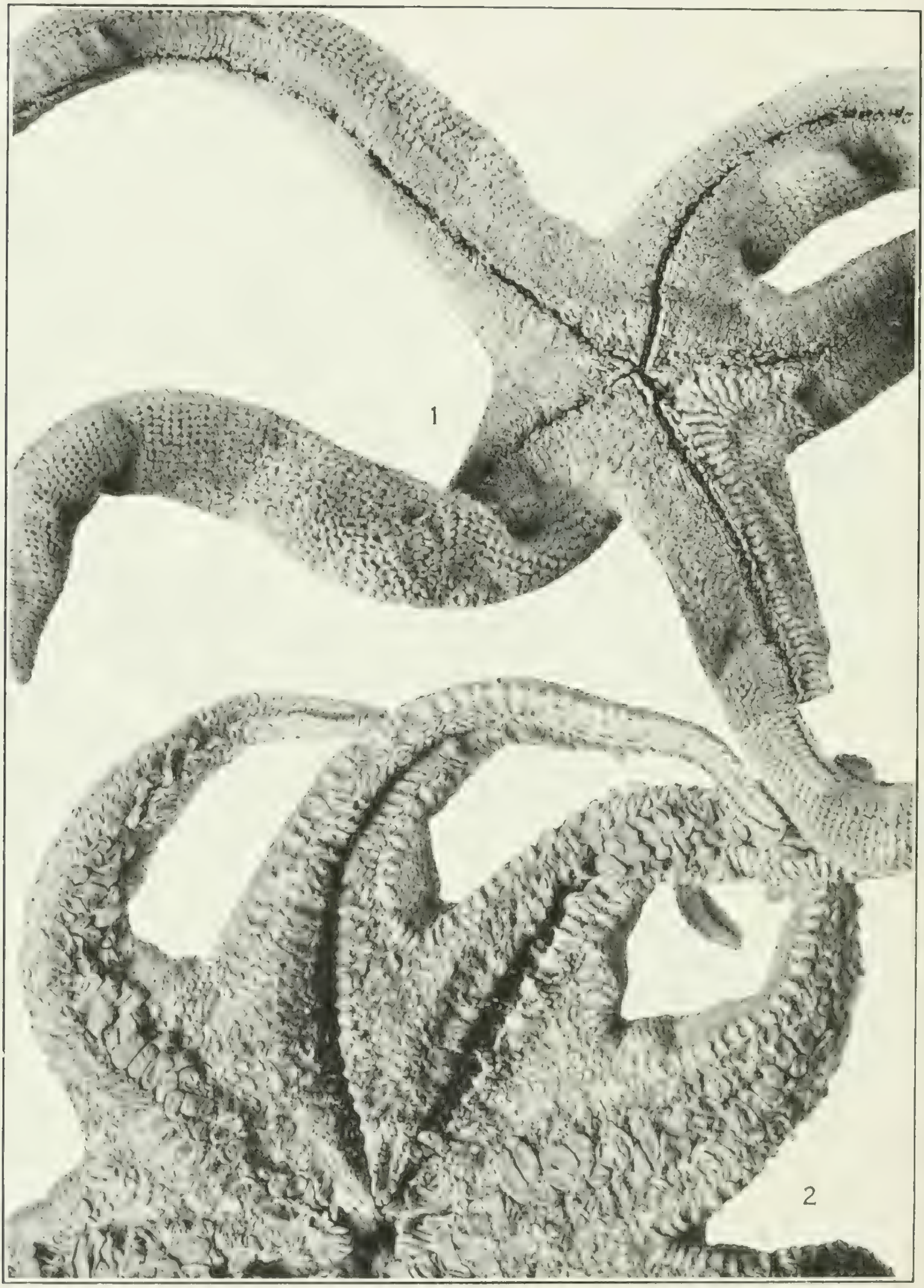
4. *Bunaster lithodes;* abactinal view of type, much enlarged, p. 398.

Plate 125.

Solaster tropicus; abactinal view of type, p. 444.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 126.

FIG. 1. *Tarachaster tenuis;* actinal view of type, enlarged: the rays are twisted so as to show also the side and dorsum. The plates of one actinal interradial area have been denuded, as also a portion of the actinal surface of one ray, p. 402.

2. *Solaster tropicus;* actinal surface of type, p. 444.

Plate 127.

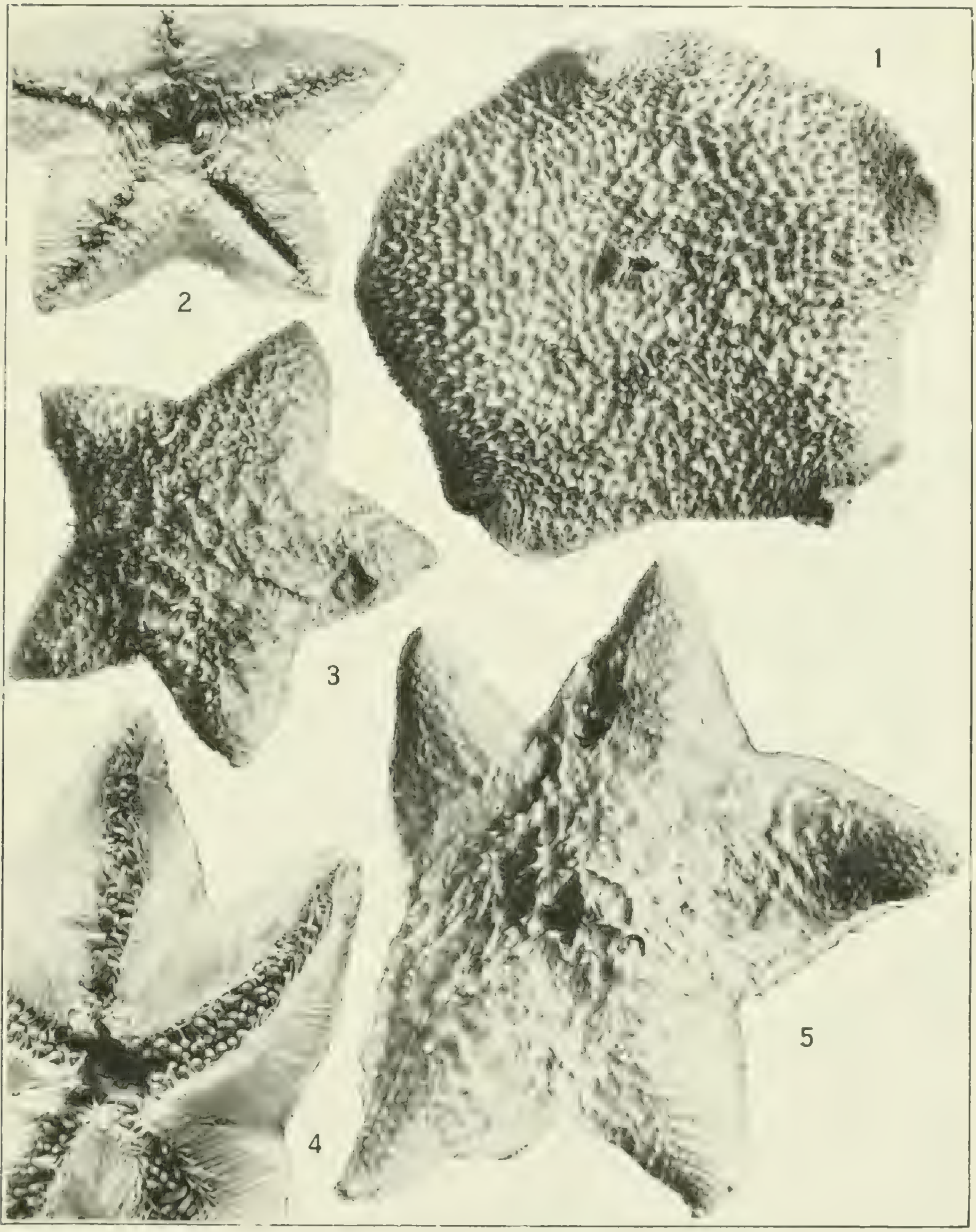
Fig. 1. *Pteraster obesus myonotus;* abactinal view of type, p. 458.

2. *Pteraster corynetes;* actinal view of type, p. 456.

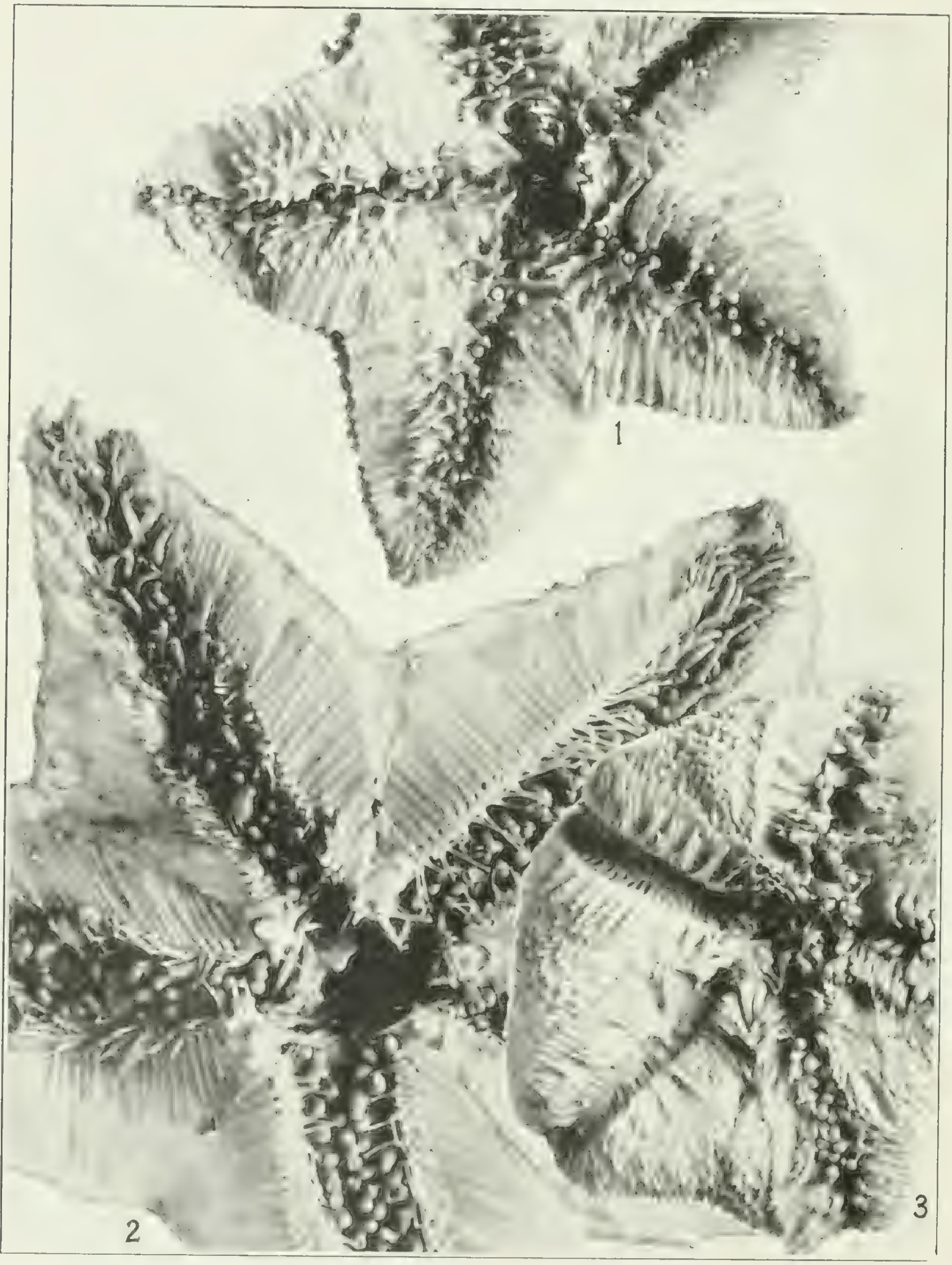
3. Same; abactinal view of type.

4. *Hymenasterides zenognathus;* actinal view of type, p. 468.

5. Same; abactinal view of type.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



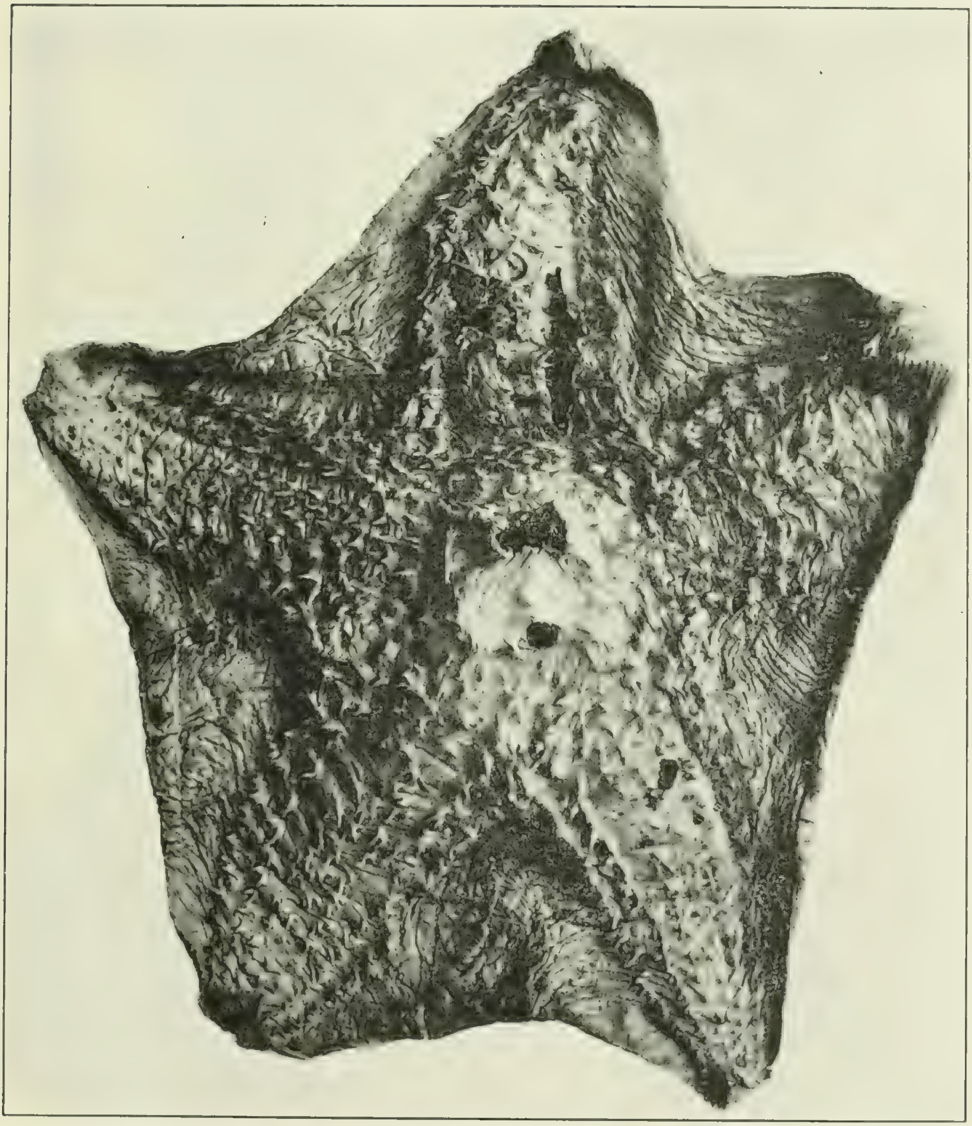
Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 128.

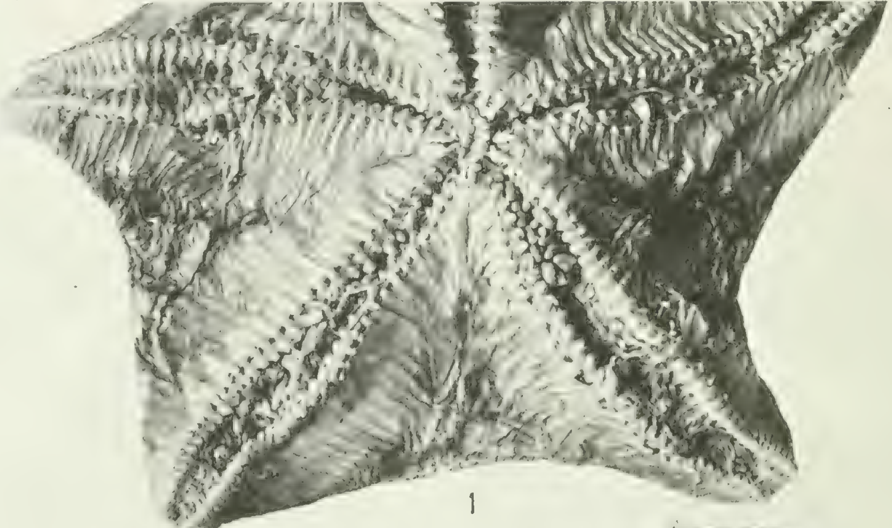
FIG. 1. *Pteraster corynetes;* actinal view of type, enlarged, p. 456.
2. *Hymenasterides zenognathus;* actinal aspect of type, much enlarged, p. 468.
3. *Pteraster obesus myonotus;* actinal view of type, enlarged, p. 458.

PLATE 129.

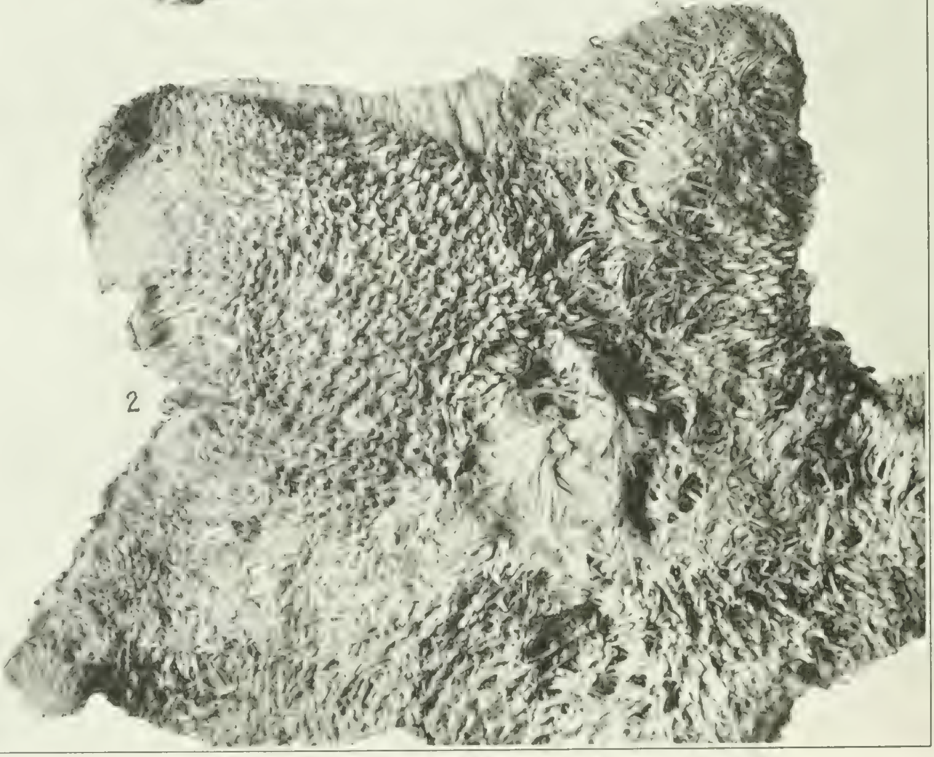
Hymenaster rhodopeplus; abactinal view of type, enlarged, p. 463.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



1



2

STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

Plate 130.

Fig. 1. *Hymenaster rhodopeplus;* actinal view of type, p. 463.
2. *Diplopteraster multipes patagiatus;* abactinal view of type, p. 462.

PLATE 131.

FIG. 1. *Dissogenes styracia*, type; radial plates, base of ray, × 6.5. 1*a*. Same; fifth and sixth adambulacral plates × 6.5. 1*b*. Same; abactinal plates with the granules removed, near middle of ray, × 4. P. 368.

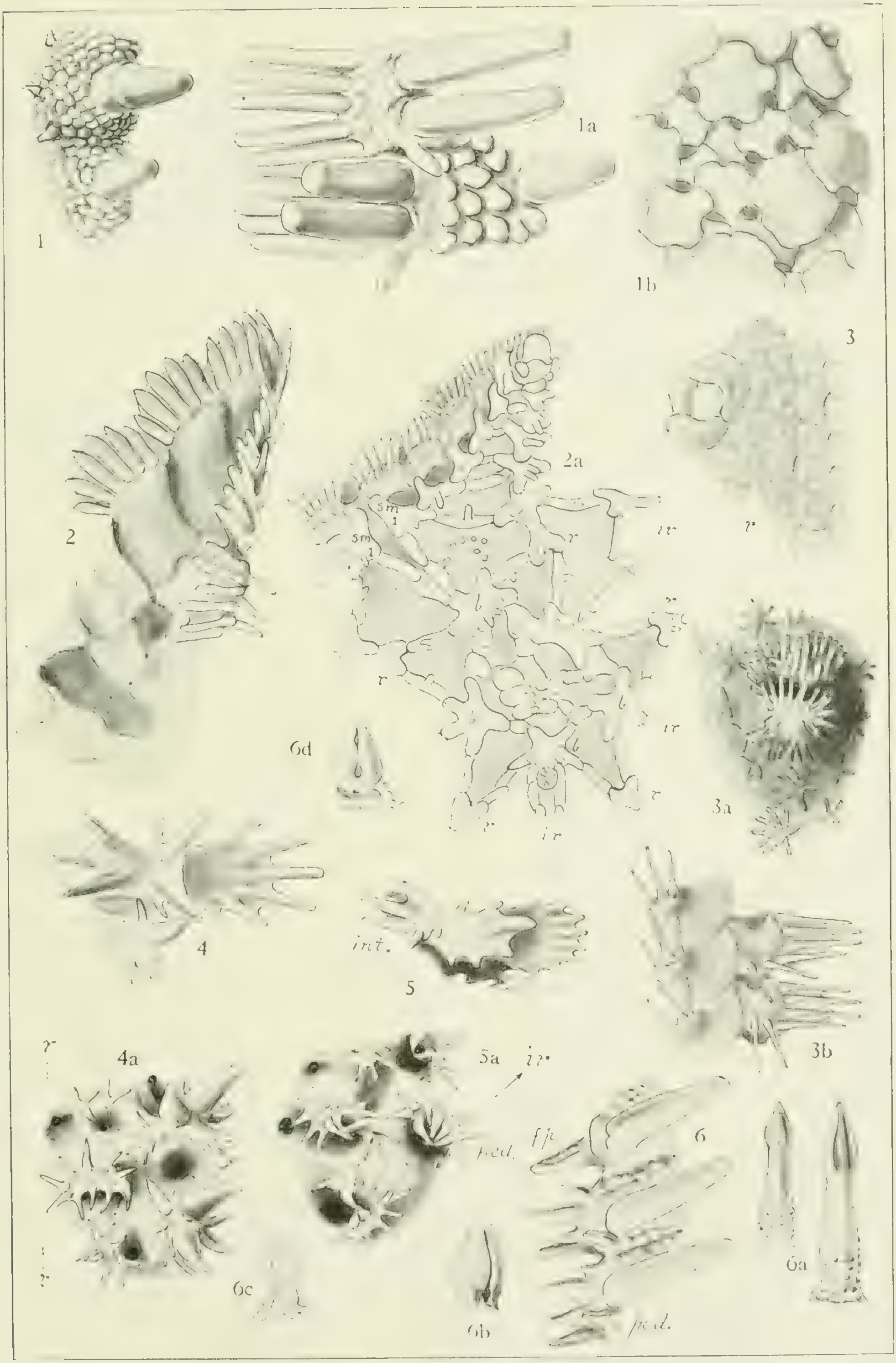
2. *Marginaster paucispinus*, type; actinal surface showing last 5 (third to seventh) inferomarginal plates, and distal adambulacrals, × 9.6. The last 2 marginals are partly hidden; *int.*, actinal intermediate plate. 2*a*. Same; abactinal surface, showing arrangement of plates, × 5; *b*, primary basal; *r*, primary radial; *sm 1*, the first superomarginal; *ir*, interradial line. P. 407.

3. *Anseropoda macropora*, type; external view of abactinal plates, showing the enlarged plates surrounding the papular pores; *r*, the radial series of plates, × 16. 3*a*. Same (cotype; one of the proximal papular pores, with enlarged and normal plates, × 16. 3*b*. Same; 2 adambulacral and 3 adjacent actinal intermediate plates. P. 424.

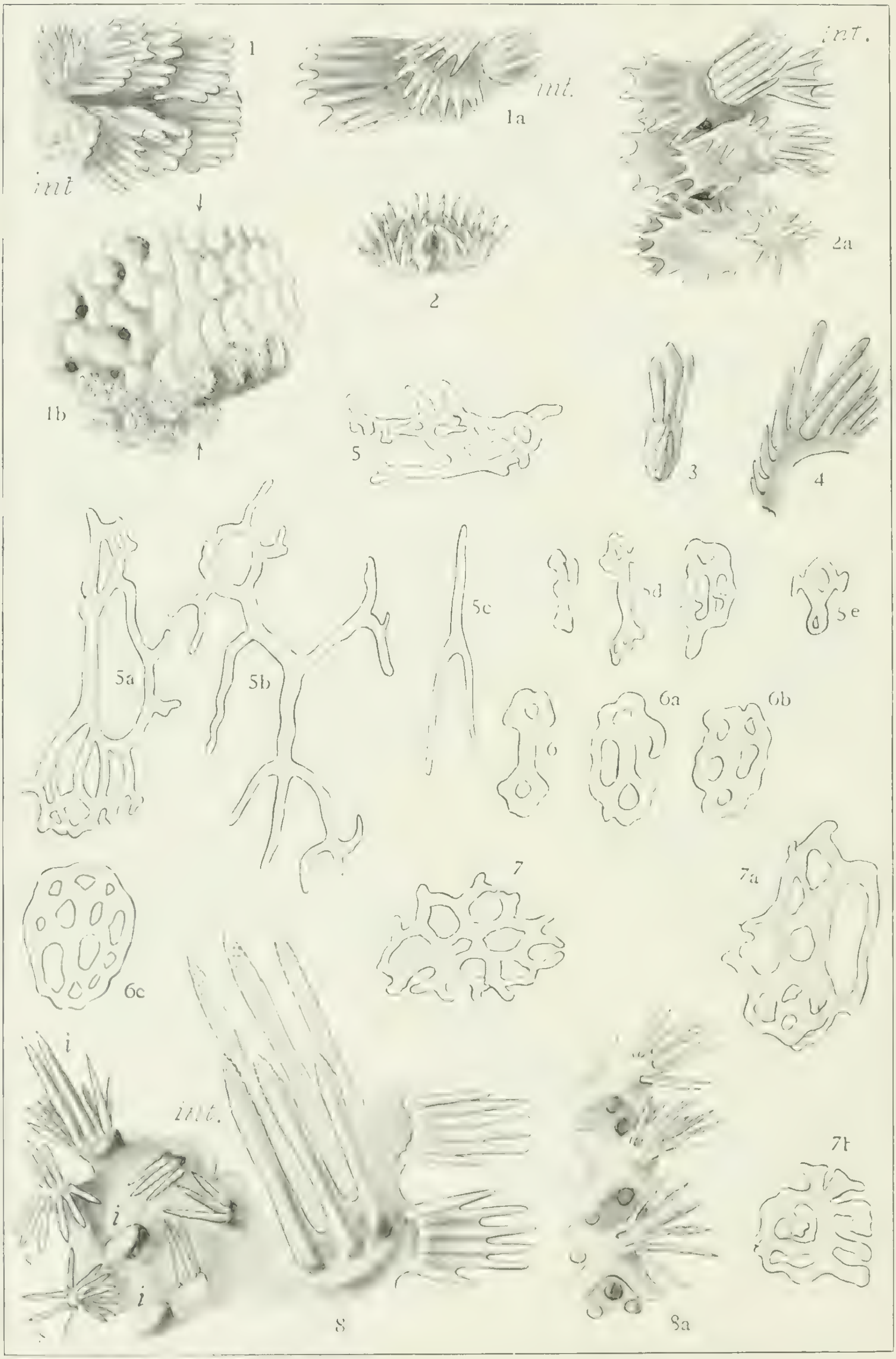
4. *Asterina coronata cristata*, type; an adambulacral plate and an actinal intermediate plate, *int.*, × 9.6. 4*a*. Same; abactinal plates adjacent to the radial line, showing, on the right, 2 of the enlarged plates, × 12. P. 411.

5. *Asterina coronata euerces*, type; an adambulacral plate, and an actinal intermediate plate to the left (*int.*), × 20. 5*a*. Same, type; abactinal plates of disk, near the interradial line (*ir*), each with a pedicellaria (*ped.*), × 12. P. 414.

6. *Acanthaster brevispinus*, cotype; 3 adambulacral plates, × 6.5; the upper, which is distad, has the furrow spines removed to show the furrow pedicellaria beneath (*fp*); note the subambulacral pedicellaria (*ped.*). 6*a*. Same; 2 abactinal spines, × 12. 6*b*, *c*, *d*. Same; 3 abactinal pedicellariae. P. 442.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 132.

FIG. 1. *Paranepanthia platydisca*, type; eleventh and twelfth adambulacral plates with the 2 adjacent actinal intermediate plates (*int.*) × 9.6. 1*a*. Same; an adambulacral and an intermediate plate (*int.*), middle of ray, × 9.6. 1*b*. Same; abactinal plates, middle of ray; the arrows mark the division between the radial and lateral areas; × 9.6. P. 420.

2. *Asterinopsis pedicellaris*, type; an abactinal plate from near interradius × 16. 2*a*. Same, tenth to twelfth adambulacral plates, with adjacent intermediate plates (*int.*), × 16. P. 417.

3. *Henricia microplax*, type; furrow face of an adambulacral plate, × 8. P. 437.

4. *Henricia arcystata*, type; profile view (adoral side) of the fifth adambulacral plate, × 8. P. 439.

5, 5*a*–5*c*. *Echinaster callosus;* deposits in skin of large specimen, × 400. 5*d*, 5*e*. Same; station 5138; deposits in skin of small specimen. P. 428.

6, 6*a*–6*e*. *Echinaster stereosomus*, type; deposits in skin, × 400. P. 430.

7, 7*a*, 7*b*. *Othilia purpurea*, station 5160; deposits in the skin, × 400. P. 432.

8. *Lophaster suluensis*, type; seventh and eighth adambulacral plates, actinal intermediate plates, fourth, fifth, and sixth inferomarginals (*i*) and 2 superomarginals (*s*). 8*a*. Same; adradial paxillae, base of ray. P. 449.

PLATE 133.

FIG. 1. *Xenorias polyctenius*, type; 2 adambulacral, 3 adjacent inferomarginal (*i*) and 2 superomarginal plates (*s*), × 8. 1*a*. Same; superomarginal and inferomarginal plates from the side, × 6.5; the spines point toward the end of the ray. 1*b*. Same; abactinal pseudopaxillae, base of ray, × 6.5. P. 451.

2. *Solaster tropicus*, type; thirteenth and fourteenth adambulacral, and adjacent actinal plates, showing the heavy investment of the spines, × 5. 2*a*. Same; abactinal plates, dried, from near median line and the proximal third of ray, × 6.5. 2*b*. Same; abactinal pseudopaxillae with the integument covering the plates and spines. P. 444.

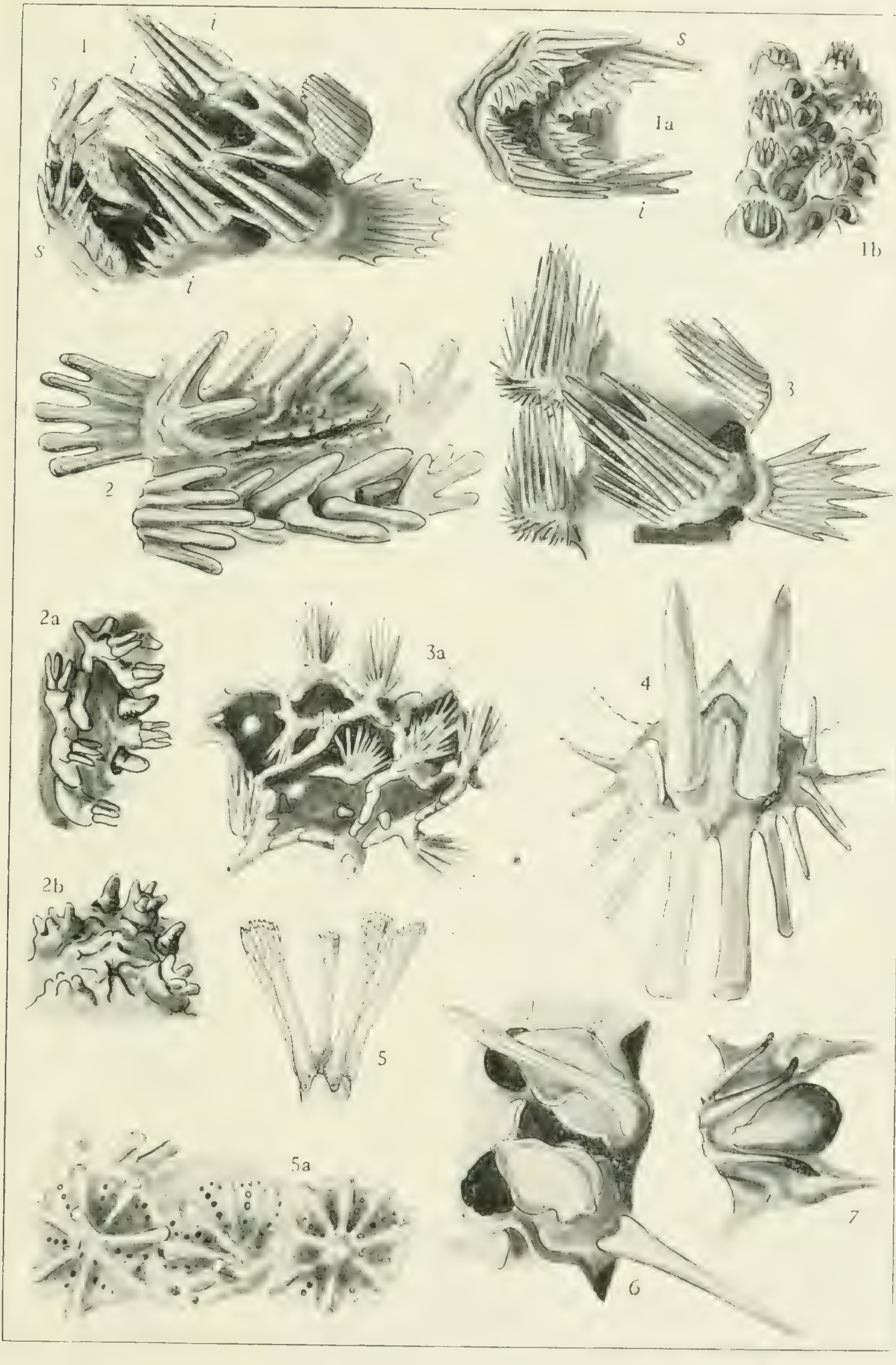
3. *Crossaster scotophilus*, type; fourteenth and fifteenth adambulacrals and adjacent inferomarginal plates, × 8. 3*a*. Same; abactinal plates at base of ray and near median line, × 6.5. P. 447.

4. *Pteraster obesus myonotus*, type; mouth plates, × 6.5. P. 458.

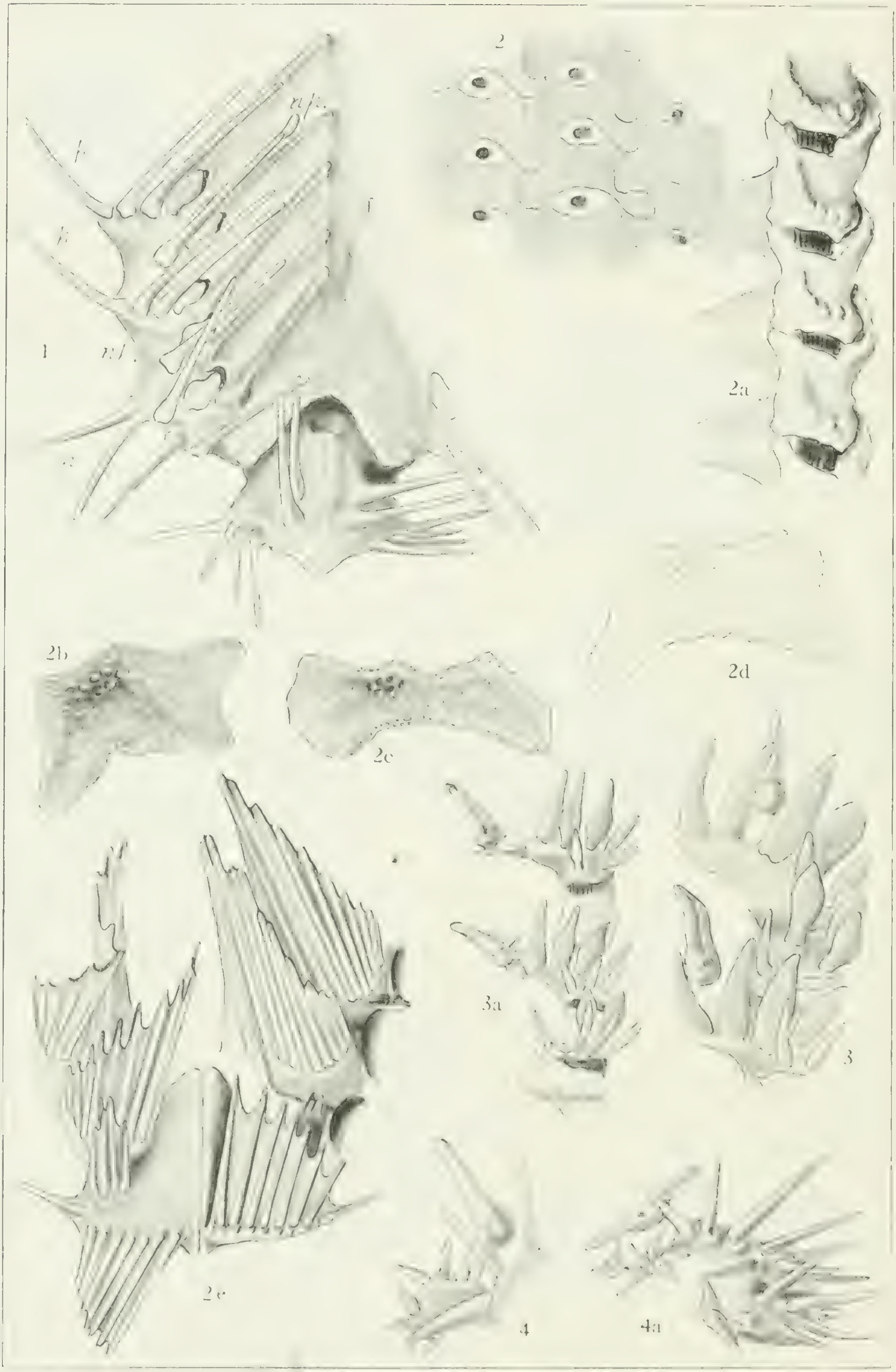
5. *Pteraster corynetes*, type; a paxilla from the side, showing 5 characteristically formed spines, × 12. 5*a*. Same; paxillae and the supradorsal membrane near center of disk, × 6.5. P. 456.

6. *Hymenaster rhodopeplus*, type; second and third adambulacral plates, × 8. P. 463.

7. *Hymenaster bartschi*, type; second adambulacral plate, × 8. P. 465.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 134.

FIG. 1. *Hymenasterides zenognathus*, type; oral angle showing mouth plates and the first 6 adambulacral plates of one side, 3 of these are obviously "prominent" plates (*p*) and between them are the alternate smaller adambulacrals, each with 1 spine (*np*), × 8. P. 468.

2. *Myxaster medusa*, type; abactinal plates from the inside, × 8. 2*a*. Same; adambulacral plates denuded of spines; the furrow margin is toward the *left;* × 4. 2 *b*, *c*, *d*. Same; 3 abactinal plates, disassociated; the attachment point of the spines is shown by the slight bosses on the plate, × 8. 2*e*. Same; oral angle, with mouth plates and 2 adambulacral fans on either side, × 2.5. P. 454.

3. *Cnemidaster wyvillii*, station 5582; 2 prominent adambulacral plates and between them a "nonprominent" plate, × 8. 3*a*. Same, station 5607; 3 "prominent" and 2 nonprominent plates; a nonprominent plate, and a prominent plate without spines, × 8. P. 480.

4. *Zoroaster microporus*, type; the furrow projection of a prominent plate from the adoral side, showing 3 furrow spines. 4*a*. Same; a "prominent" and a "nonprominent" plate, actinal view, × 8. P. 475.

PLATE 135.

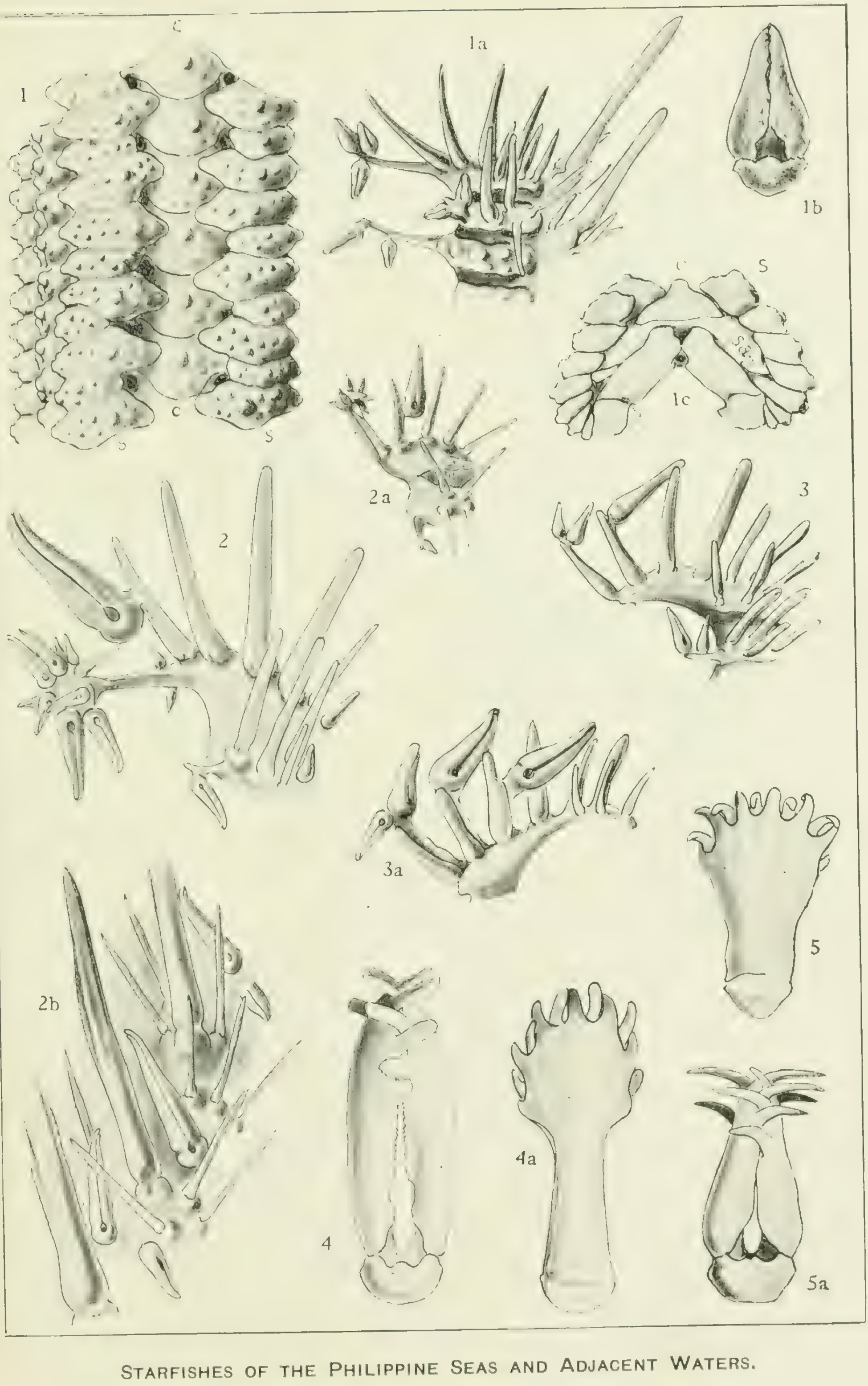
FIG. 1. *Bythiolophus acanthinus*, type; abactinal plates and on the left, 3 series of lateral plates; *c*, carinal or radial series; *s*, superomarginal plates; the spines have all been removed, × 4. 1*a*. Same; 3 adambulacral plates, from proximal third of the ray, × 9.6; on the right 2 lateral spines of the lowermost series are shown. 1*b*. Same; a pedicellaria from an adambulacral spine, enlarged. 1*c*. Same; cross section of a ray × 3.2; *c*, carinal plates; *s*, superomarginal plates; *i*, inferomarginal plates; *sa*, superambulacral plates. P. 484.

2. *Zoroaster ophiactis*, type; 2 adambulacral plates, × 8. 2*a*. Same, station 5684, specimen with R=120 mm.; 2 adambulacral plates. 2*b*. Same, type; side view of ray showing spines and pedicellariae, × 8; 1 large spine is shown from each of the 3 lowest tiers of lateral plates, near base of ray. P. 473.

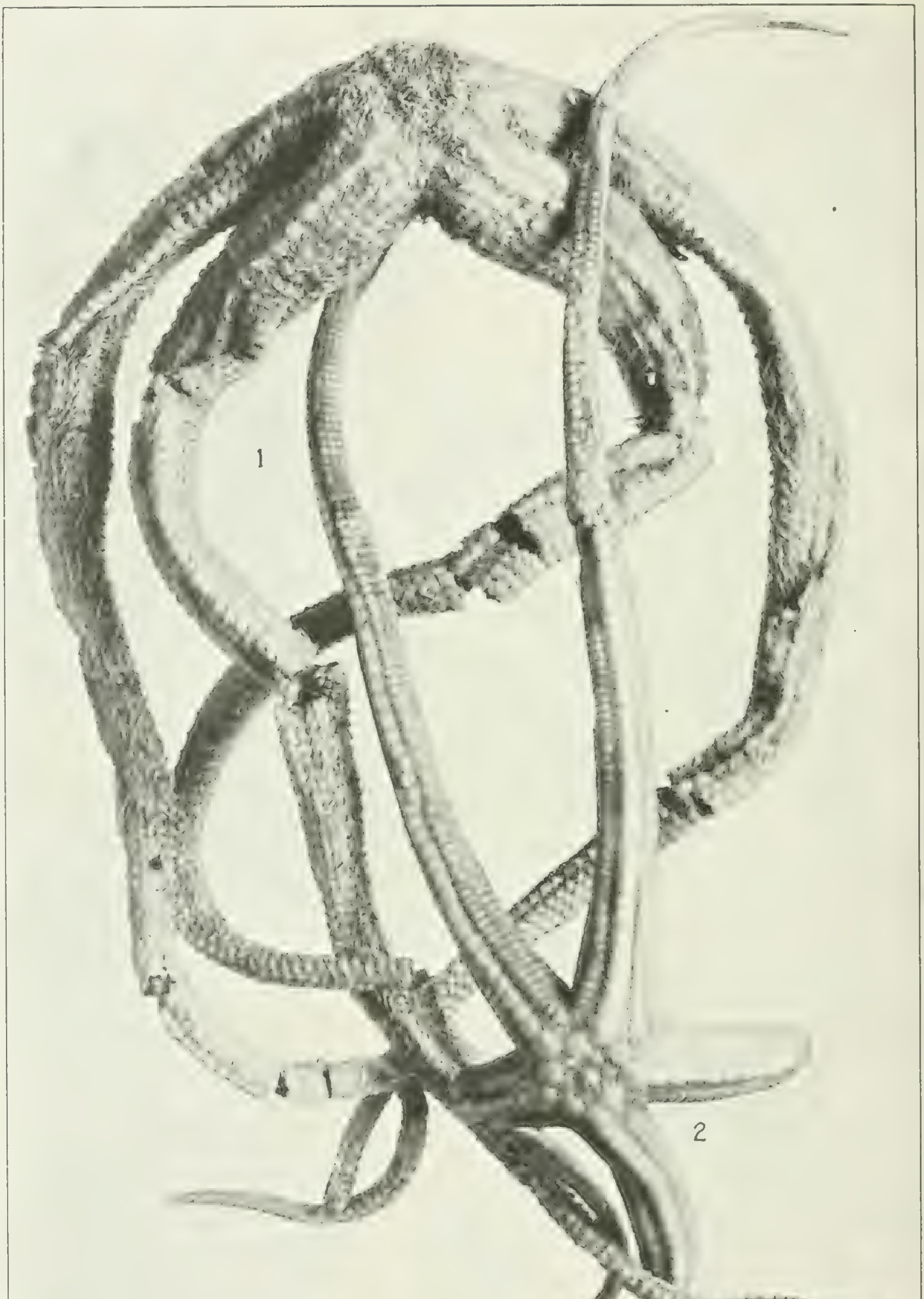
3. *Zoroaster carinatus philippinensis*, type; 2 adambulacral plates; the adoral side is below; × 8. 3*a*. Same, type; profile view from adoral side of a prominent adambulacral plate, × 8. P. 477.

4. *Coronaster volsellatus;* major pedicellaria, length about 1.75 mm., × 20 4*a*. Same; another view of a major pedicellaria. P. 496.

5. *Coronaster halicepus*, type; a major pedicellaria, length about 1.5 mm., × 20. 5*a*. Same; profile view of a major pedicellaria, × 20. P. 497.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

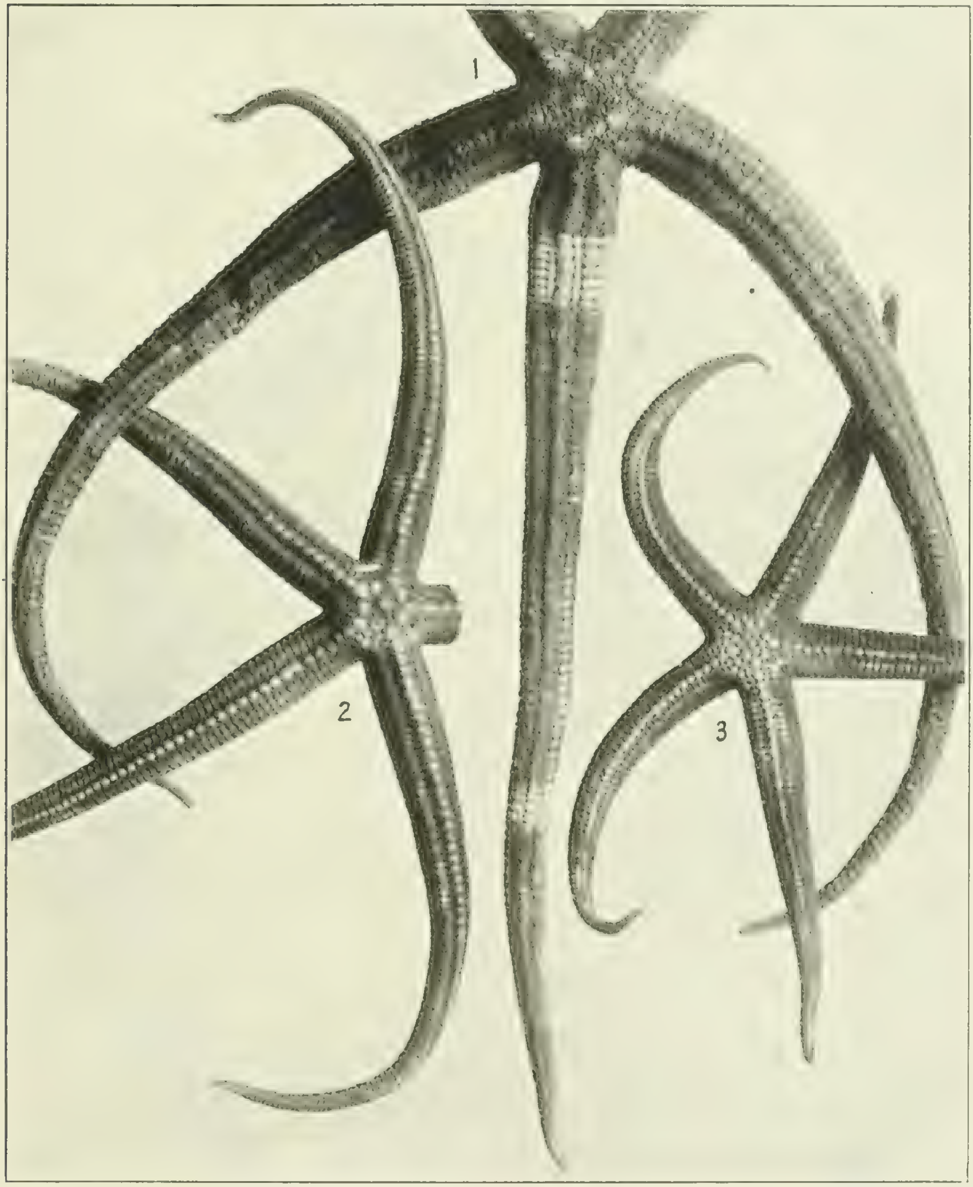
PLATE 136.

FIG. 1. *Zoroaster ophiactis*, type; the longest ray reaches to lower right corner of plate, p. 473.

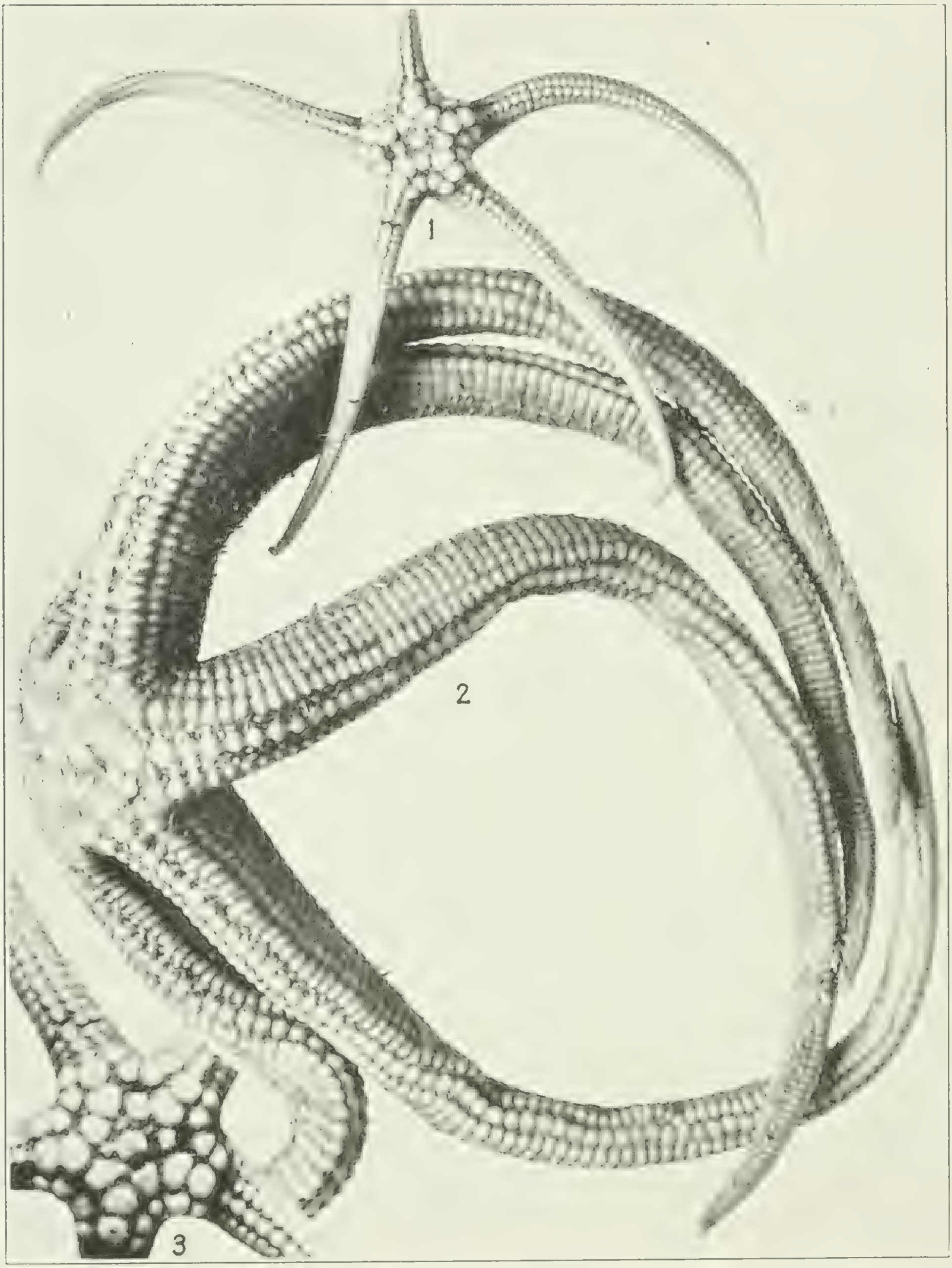
2. *Zoroaster microporus*, type; a mutilated ray on the right side has the plates denuded, p. 475.

PLATE 137.

Zoroaster carinatus philippinensis, abactinal view of the type (largest) and 2 partly grown specimens, reduced, p. 477.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 138.

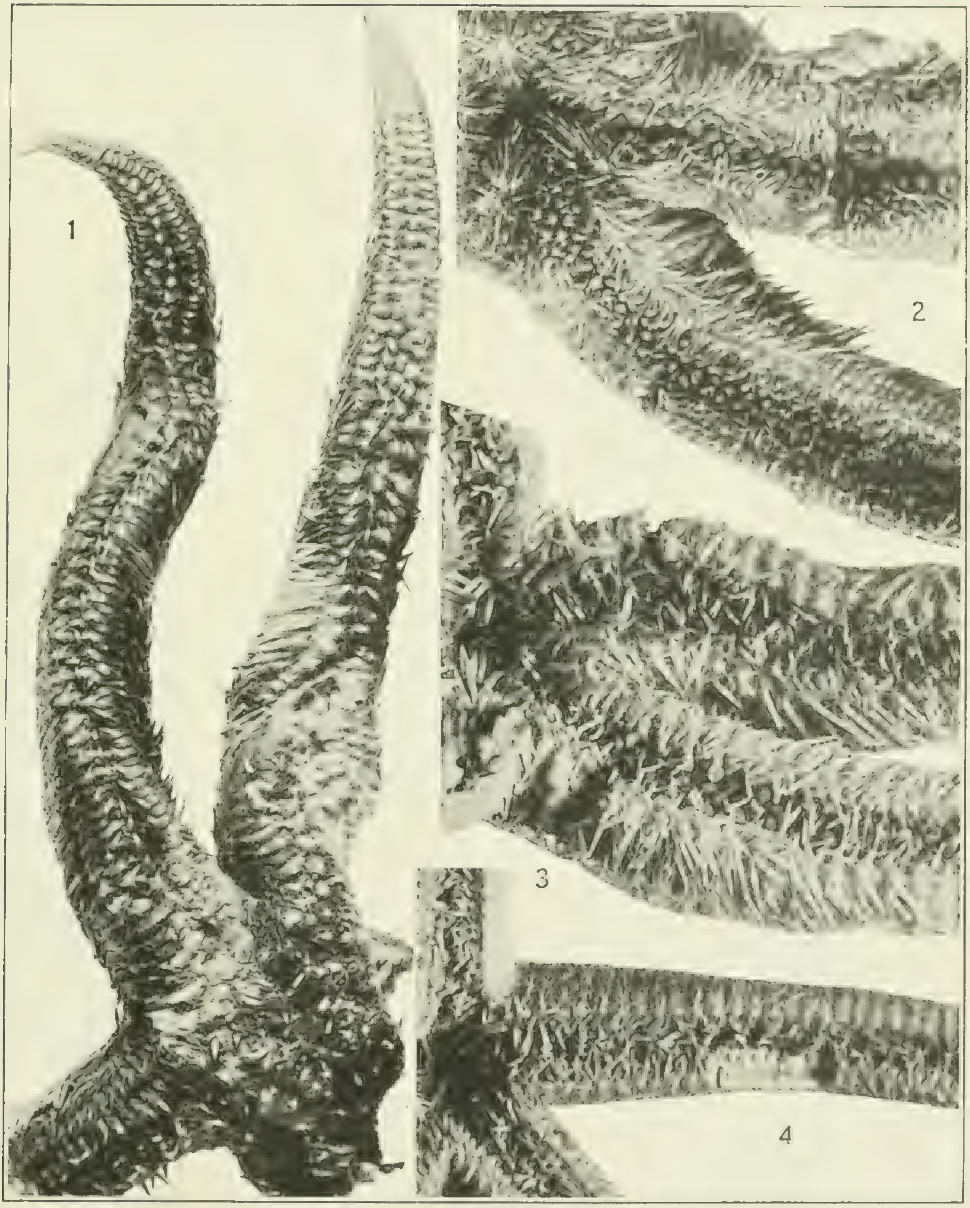
Cnemidaster wyvillii, abactinal aspect.

FIG. 1. Immature specimen, p. 480.
2. Mature specimen.
3. Disk of 1, considerably enlarged.

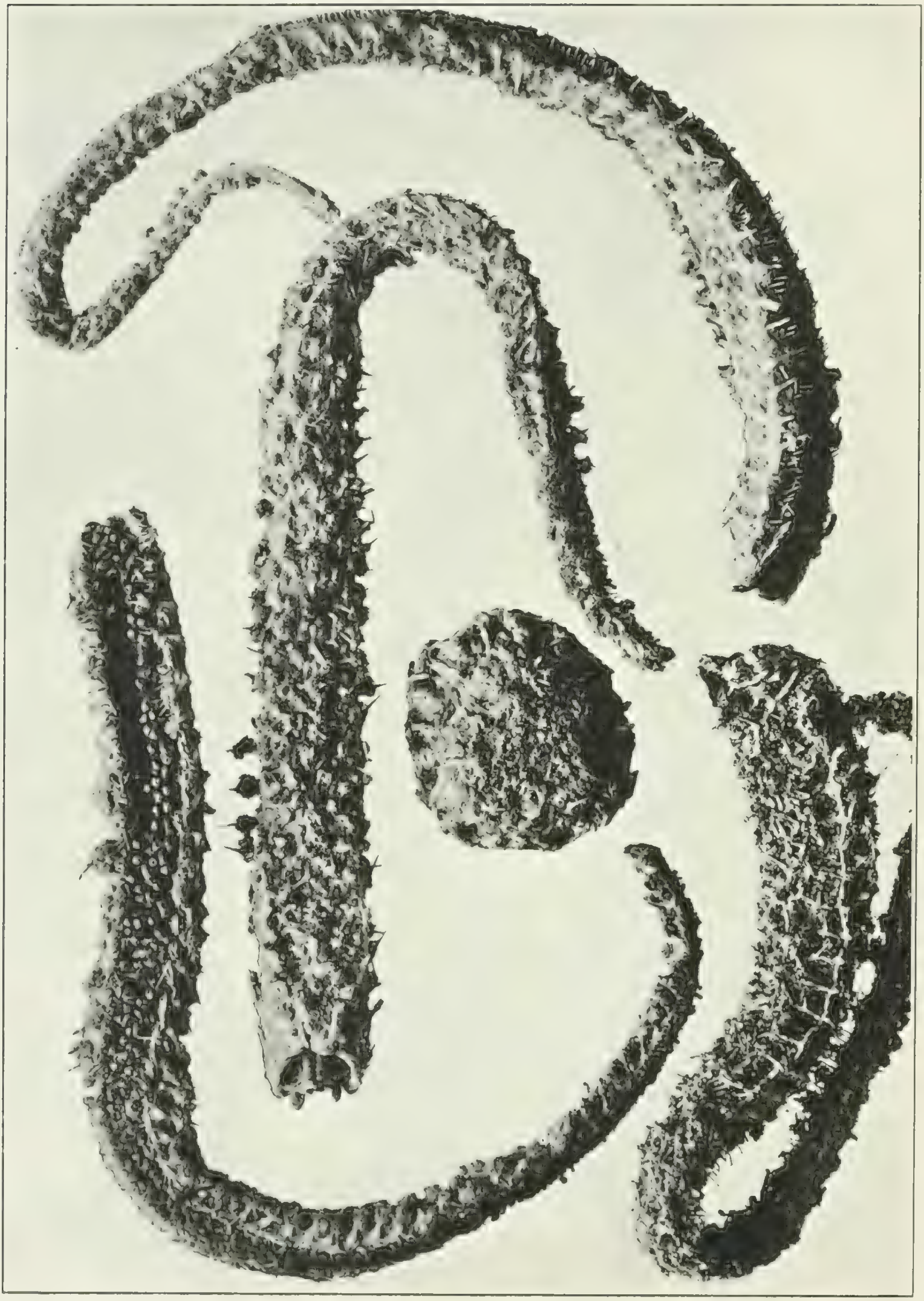
PLATE 139.

FIG. 1. *Bythiolophus acanthinus;* abactinal aspect of type, enlarged, p. 485.

2. Same; portion of actinal surface of type, enlarged, p. 485.
3. *Zoroaster ophiactis;* portion of actinal surface of type, enlarged, p. 473.
4. *Zoroaster microporus;* portion of actinal surface of type, slightly enlarged, p. 475.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



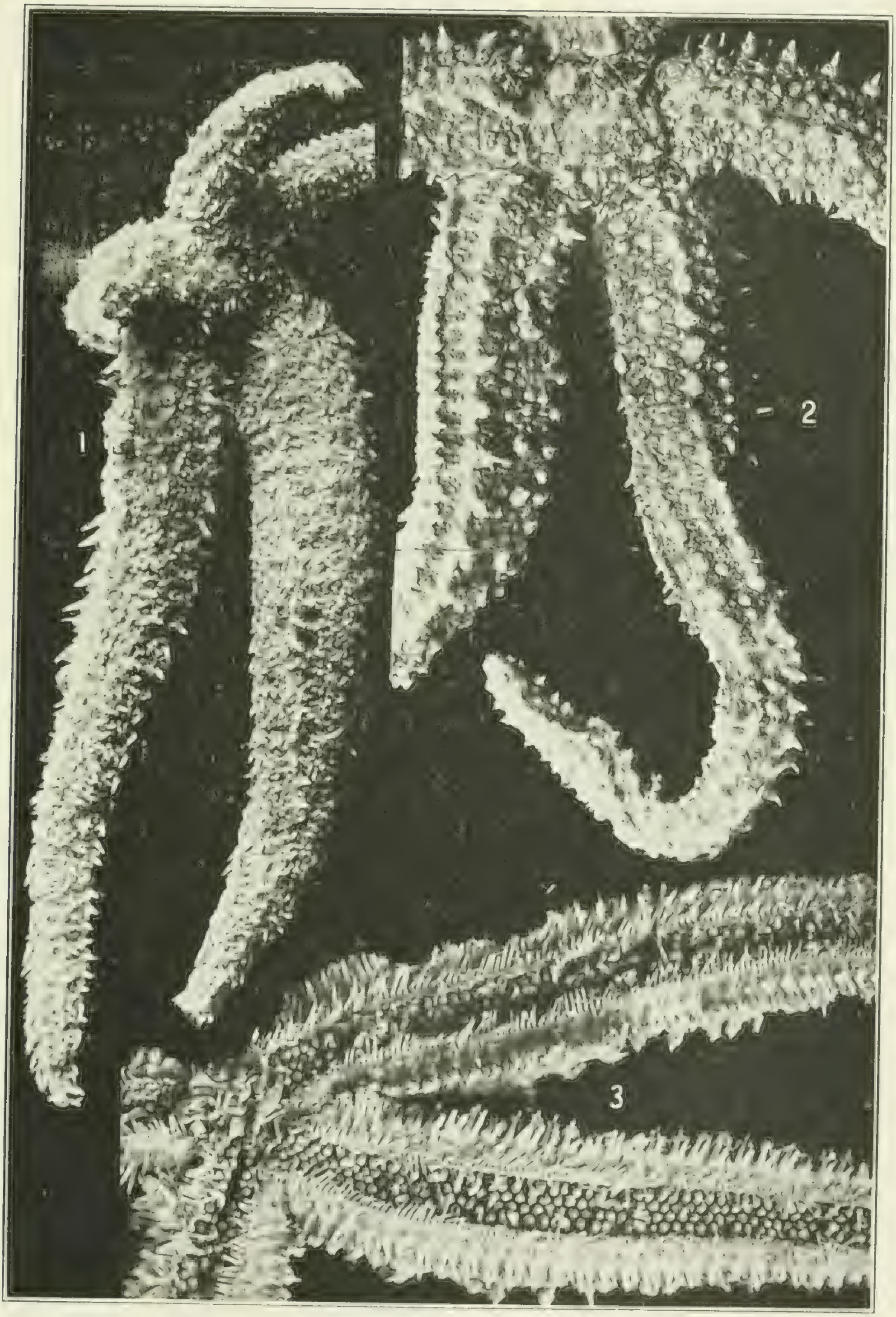
Starfishes of the Philippine Seas and Adjacent Waters.

Plate 140.

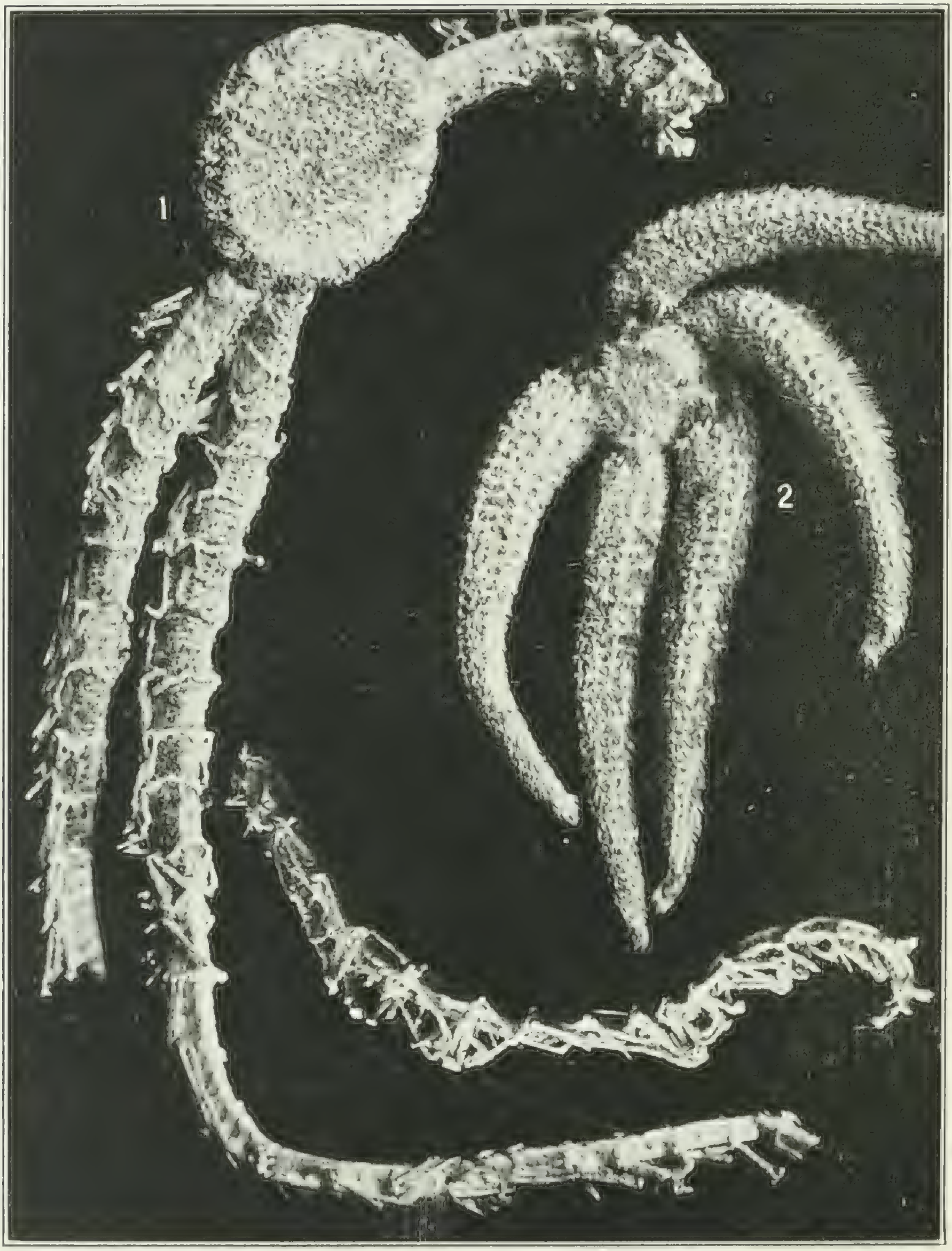
Coronaster halicepus; disk and 4 rays of type, p. 497.

PLATE 141.

FIG. 1. *Tarsaster distichopus;* abactinal view of type, enlarged, p. 490.
2. *Distolasterias hypacanthus;* abactinal view of cotype, p. 487.
3. Same; actinal view of type.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 142.

FIG. 1. *Odinia penichra*, type; abactinal view enlarged; side view of terminal portion of ray on the right, p. 505.

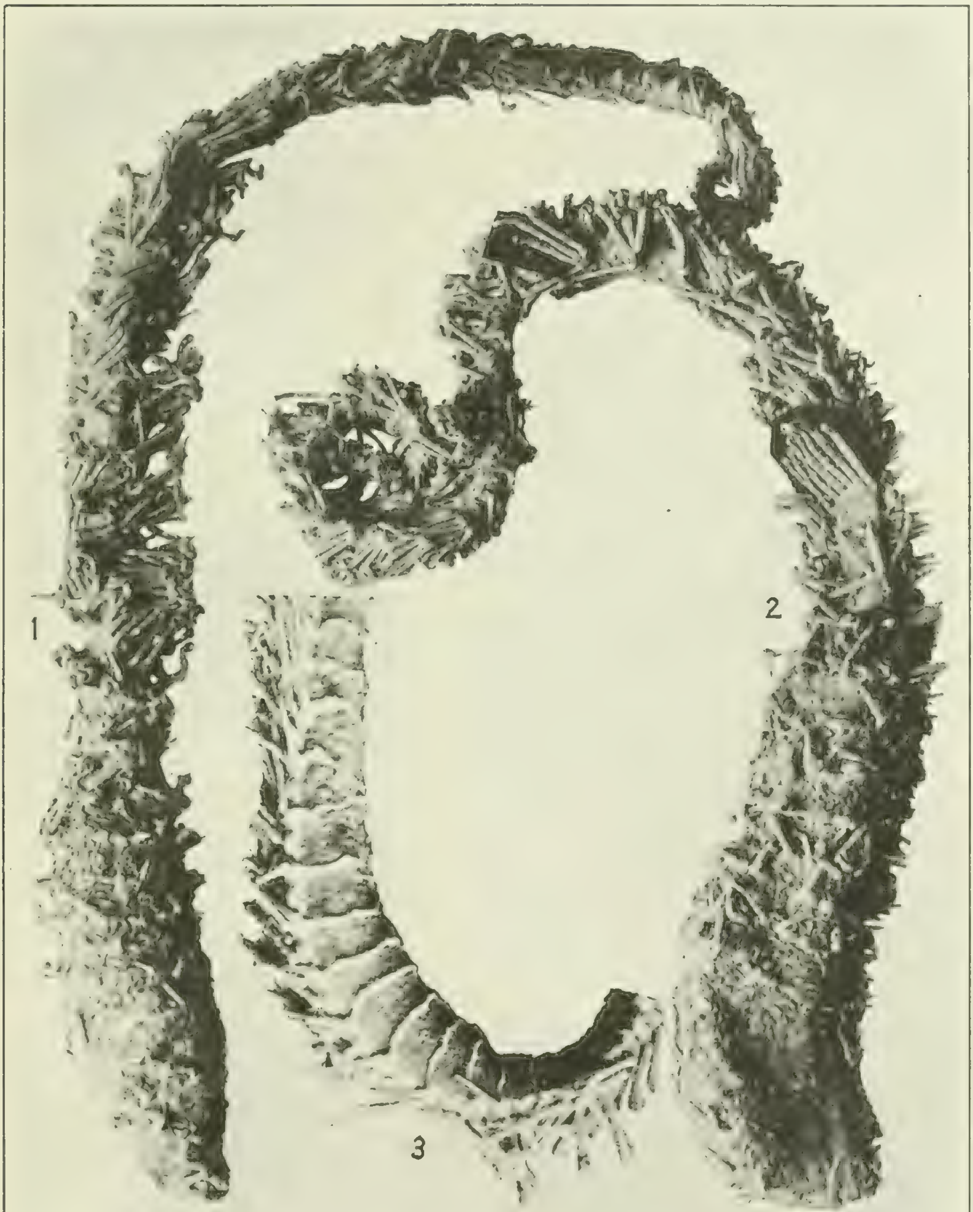
2. *Pedicellaster chirophorus*, type; abactinal aspect, enlarged, p. 499.

PLATE 143.

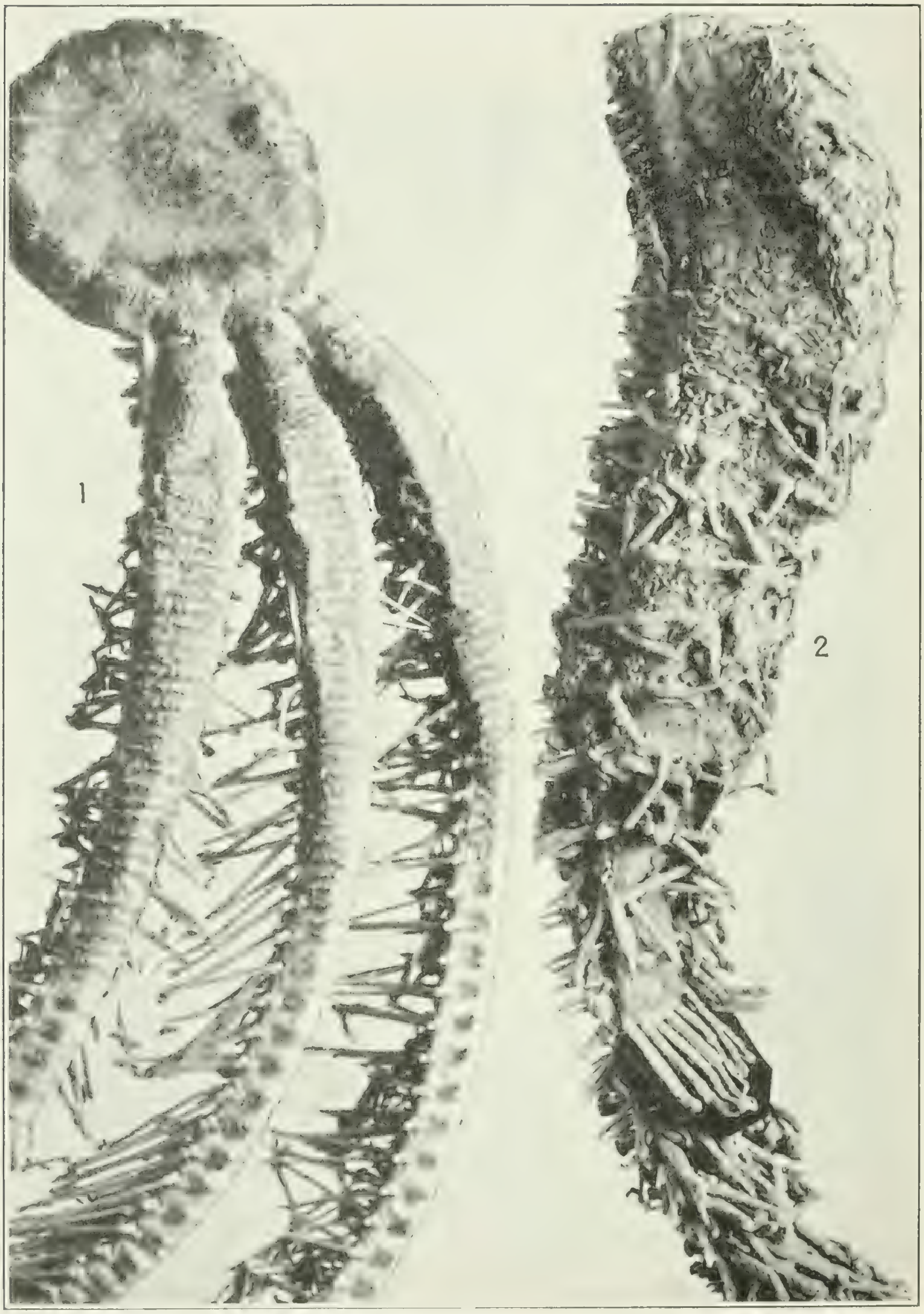
FIG. 1. *Odinia magister*, type; abactinal aspect of ray, reduced, p. 507.

2. Same; lateral aspect of ray. A piece of black paper has been placed back of 2 lateral combs.

3. *Craterobrisinga eucoryne*, type; lateral view of ray, p. 514.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



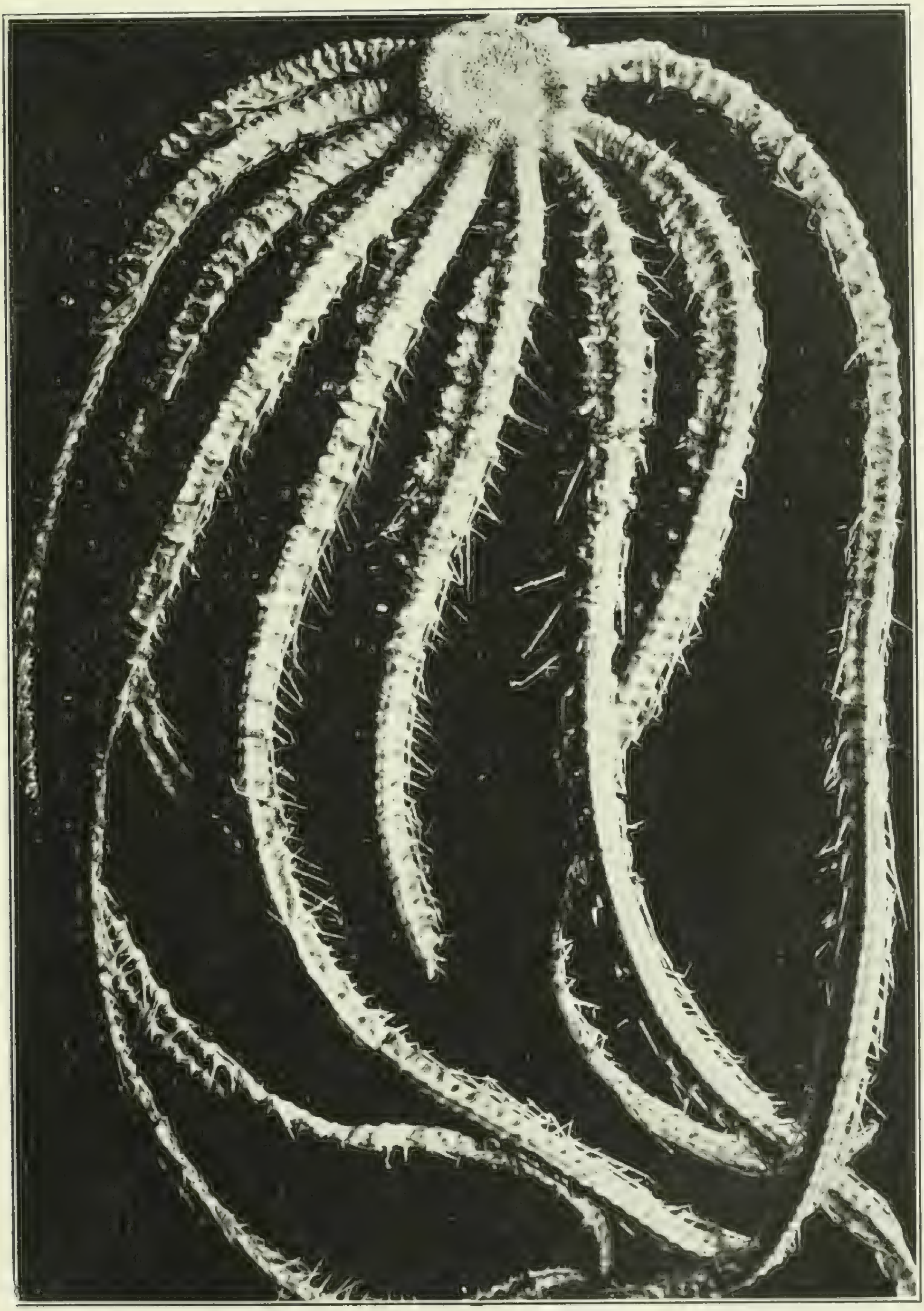
STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 144.

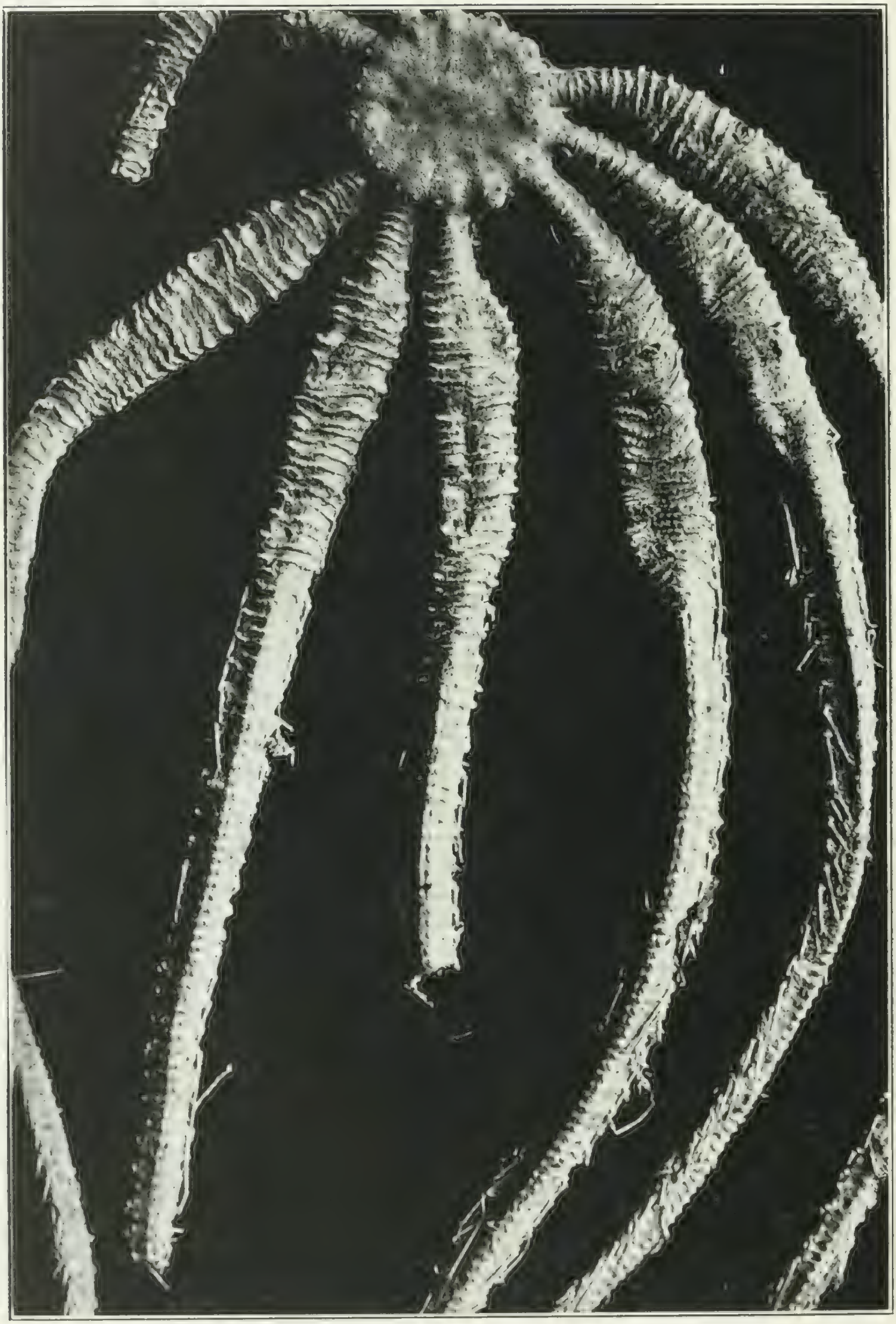
FIG. 1. *Freyellaster spatulifer;* type, enlarged, p. 538.
2. *Odinia magister;* side view of ray, enlarged, p. 507.

PLATE 145.

Brisinga trachydisca; abactinal view of type, reduced, p. 540.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

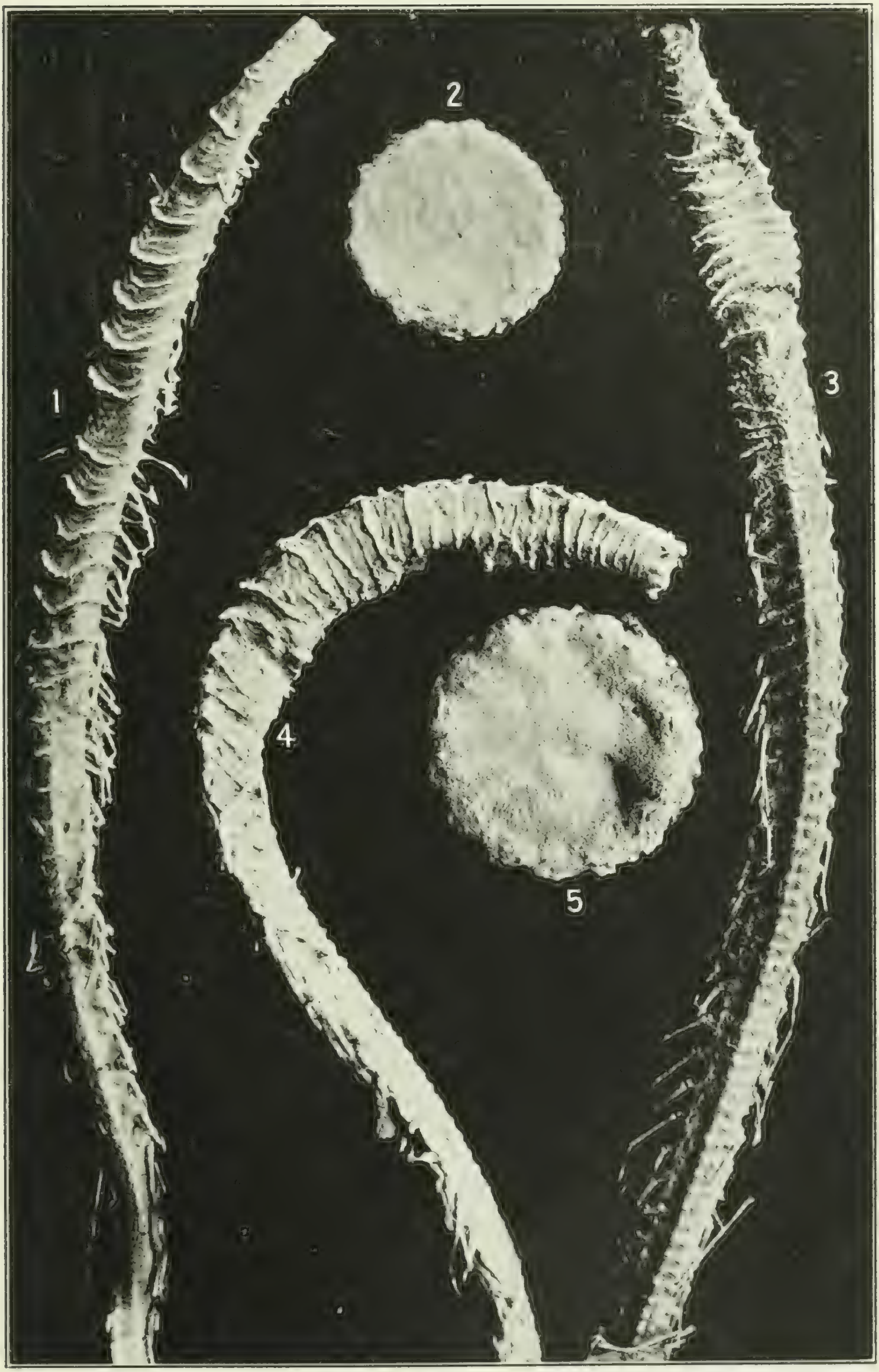
PLATE 146.

Brisingenes anchista; abactinal view of type, reduced, p. 521.

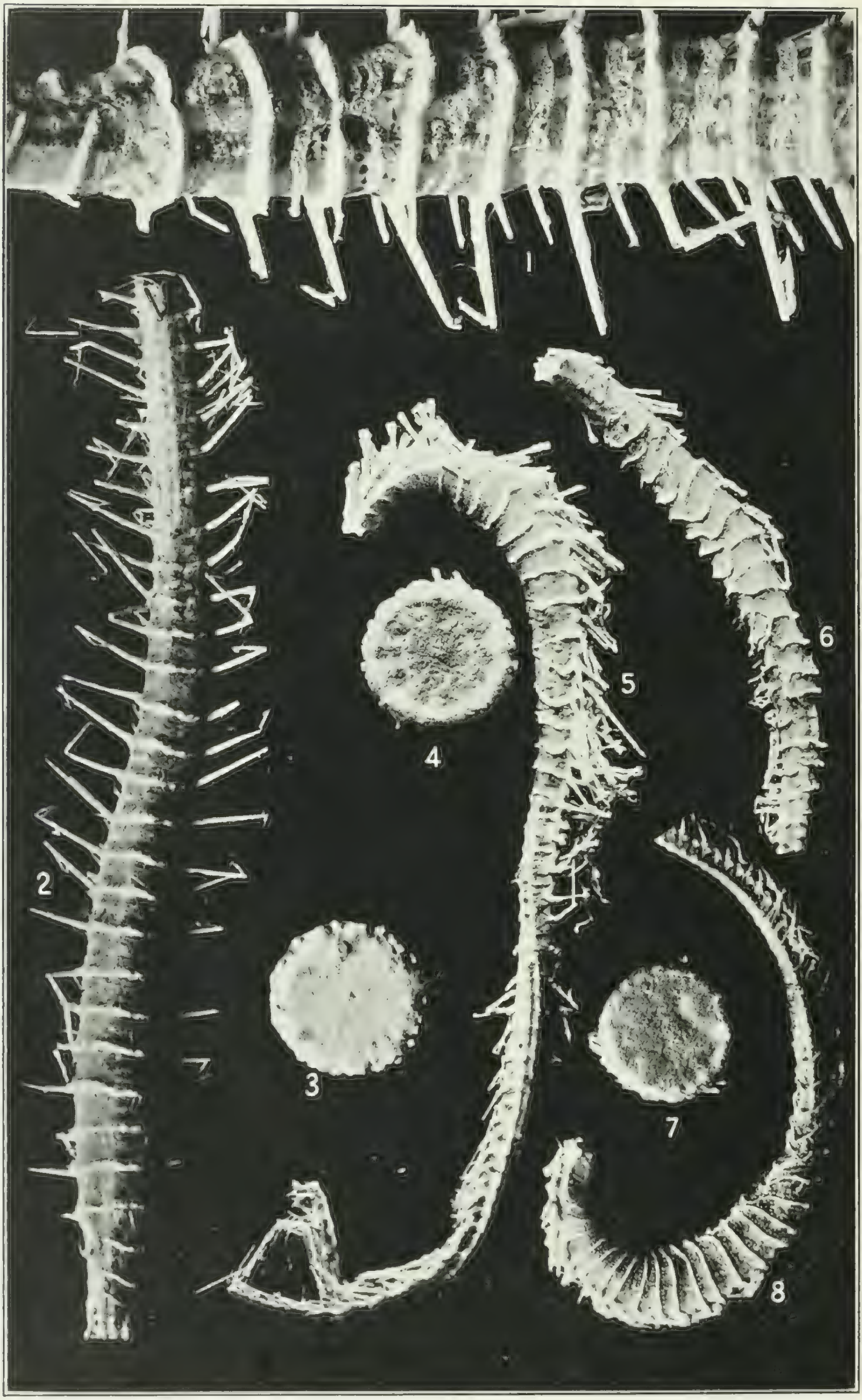
Plate 147.

Figs. 1, 2. *Astrostephane moluccana;* abactinal view of costal region of a ray and disk of the type, p. 526.

3, 4, 5. *Brisingenes mimica*; the disk, and 2 rays of the type, p. 518.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 148.

FIGS. 1, 2, 3. *Astrostephane acanthogenys;* type. Fig. 1 is much enlarged, p. 528.

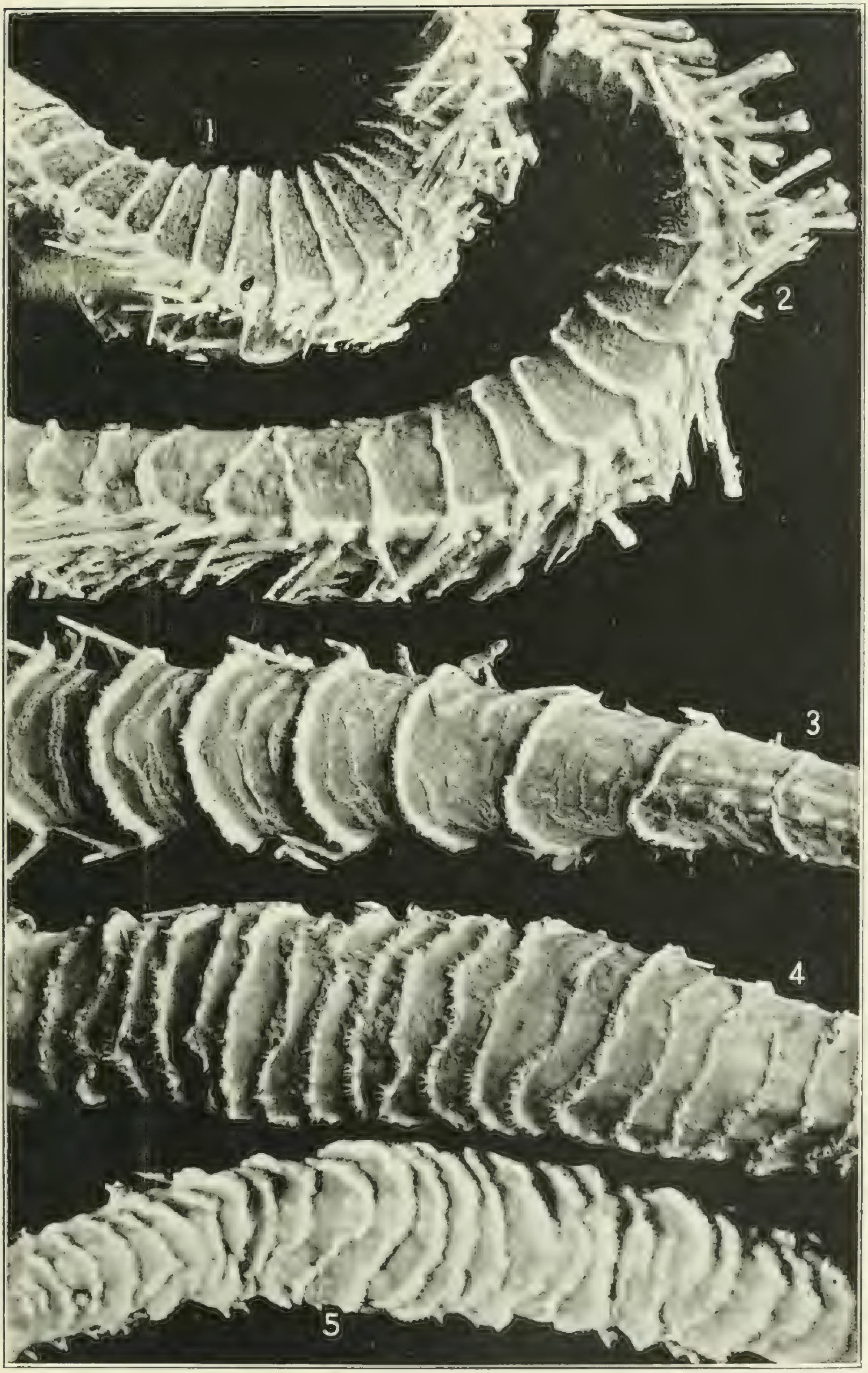
4, 5, 6. *Craterobrisinga eucoryne;* disk and 2 rays of type, p. 514.

7, 8. *Craterobrisinga analoga;* disk and ray of type, p. 516.

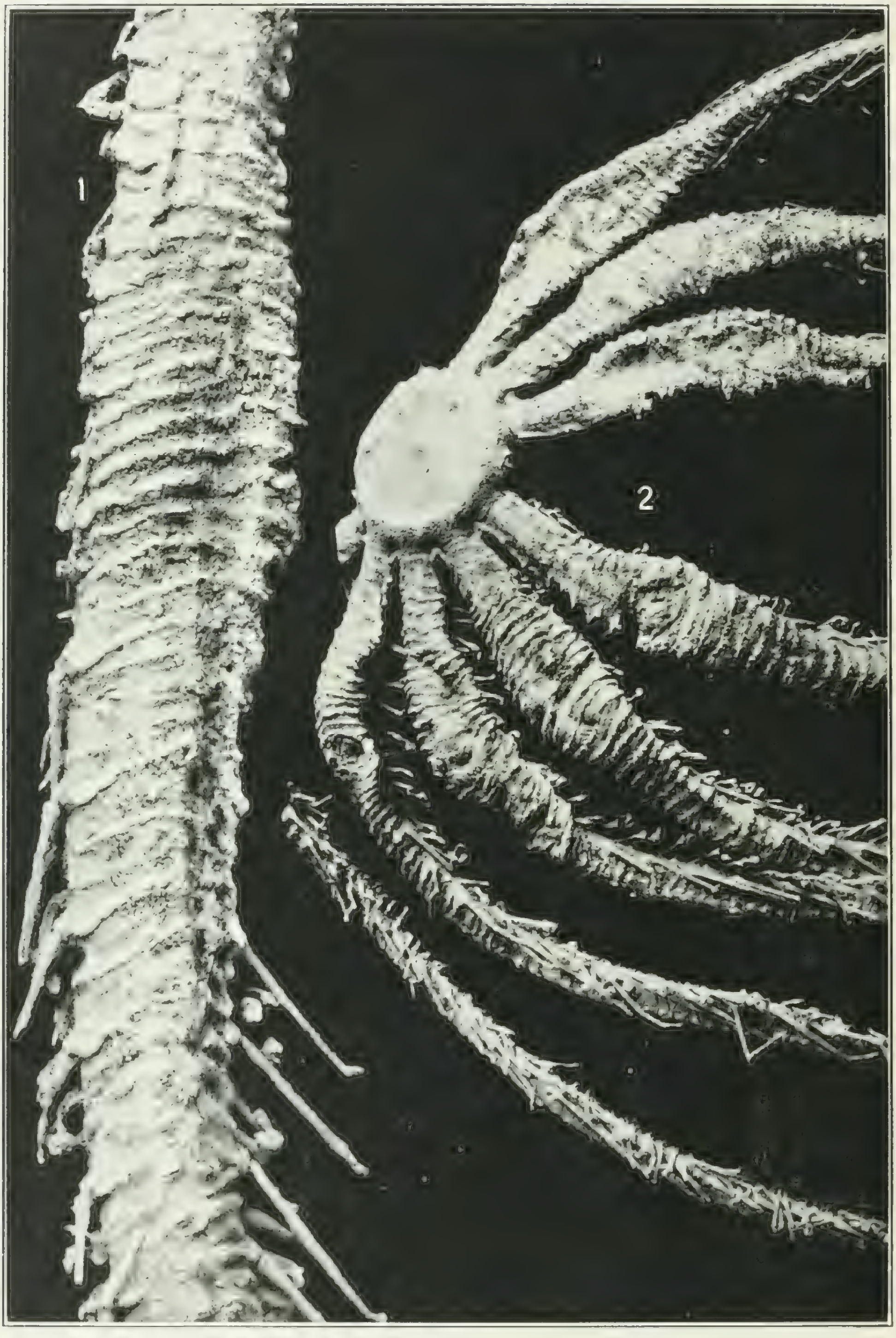
Plate 149.

Enlarged details of rays.

Fig. 1. *Craterobrisinga analoga;* side view, p. 516.
2. *Craterobrisinga eucoryne;* side view, p. 514.
3. *Astrostephane moluccana*, p. 526.
4. *Brisingenes mimica*, p. 518.
5. *Brisinga trachydisca*, p. 510.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 150.

Stegnobrisinga placoderma, type.

FIG. 1. Enlarged view of a portion of the costal region of a dried ray, p. 531.
2. Abactinal view, reduced.

PLATE 151.

FIG. 1. *Coronaster halicepus*, type; an inferomarginal spine, and 5 adambulacral plates, showing major and minor pedicellariae, × 6.5. 1*a*. Same; mouth plates; 2 large major pedicellariae are attached on the middle of the actinostomial margin; × 6.5. 1*b*. Same; a pedicellaria (length, 1.25 mm.) from adambulacral plate, × 40. 1*c*. Same; a pedicellaria (length, 0.58 mm.) from a superomarginal spine, × 60 (compare with 2, 2*a*). 1*d*. Same; a pedicellaria from skin of side wall of ray. P. 497.

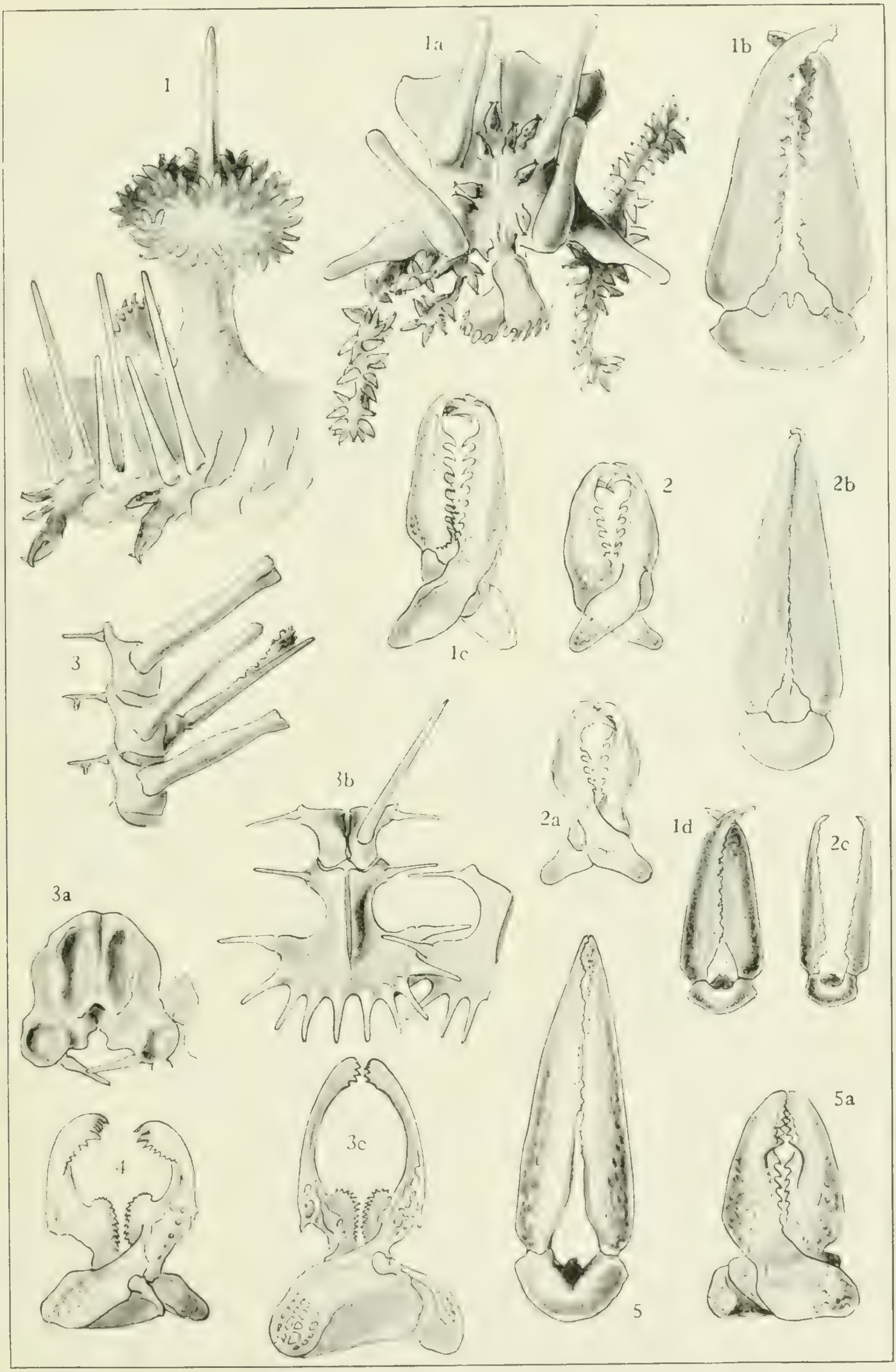
2, 2*a*. *Coronaster volsellatus*, station 5391; pedicellariae from marginal spines (length, 0.45 mm.), × 60. 2*b*. Same; large pedicellaria from adambulacral plate, × 40 (compare with 1*b*). 2*c*. Same; pedicellaria from skin of side of ray (compare with 1*d*). P. 496.

3. *Odinia penichra*, type; thirteenth to fifteenth adambulacral plates, costal region, × 8; one lateral spine and plate are shown. P. 505.

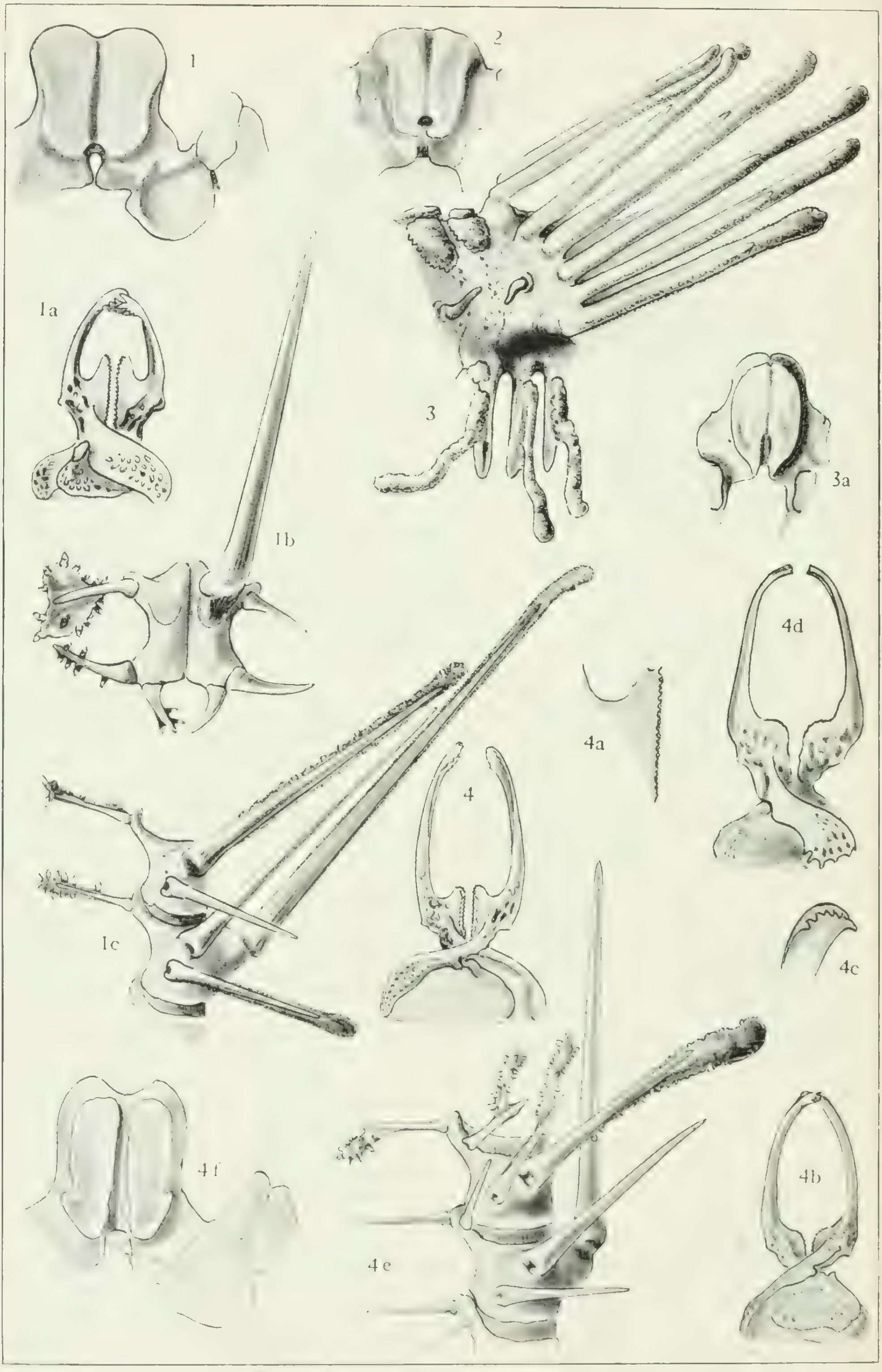
3*a*. Same; articulating surface of ambulacral plates of disk, where ray has been broken off, × 8. 3*b*. Same; mouth plates and first pair of adambulacrals, × 8. 3*c*. Same; pedicellaria (length, 0.25 mm.) from small furrow spine, near base of ray, × 160.

4. *Odinia magister*, type; a pedicellaria from a subambulacral spine (length, 0.13 mm.), × 200. P. 507.

5. *Distolasterias hypacantha*, type; major pedicellaria (length, 1.25 mm.) from dorsal integument, × 40. 5*a*. Same; pedicellaria from dorsal spine (length, 0.36 mm.), × 80. P. 487.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 152.

FIG. 1. *Brisinga trachydisca*, station 5487; articulating surface of ambulacral plates of disk, where ray has been broken off, × 5. 1*a*. Same; a pedicellaria from a small adambulacral spine, × 120. 1*b*. Same; mouth plates. × 5; only 1 of the suboral spines shown. 1*c*. Same, type; adambulacral plates from middle of costal region, × 5; 1 lateral spine is shown. P. 510.

2. *Odinia pacifica*, Hawaiian Islands; articulating surface of adambulacral plates at base of ray, where it has been detached from disk, for comparison with 3*a*; × 5. P. 509.

3. *Odinia magister*, type; side view of ray at end of the papular region to show the comb of spines (only one comb shown), the adambulacral spines, and the cushions of pedicellariae, × 2.5. The sacculi are shown extending their full length beyond the tips of the laterial spines proper; in life they are undoubtedly much longer. 3*a*. Same; articulating surface of the adambulacral plates at base of ray, for comparison with fig. 2; × 2.5. Ordinarily the opposite facet, that of the disk, has been figured, but the disk is wanting in the type. P. 507.

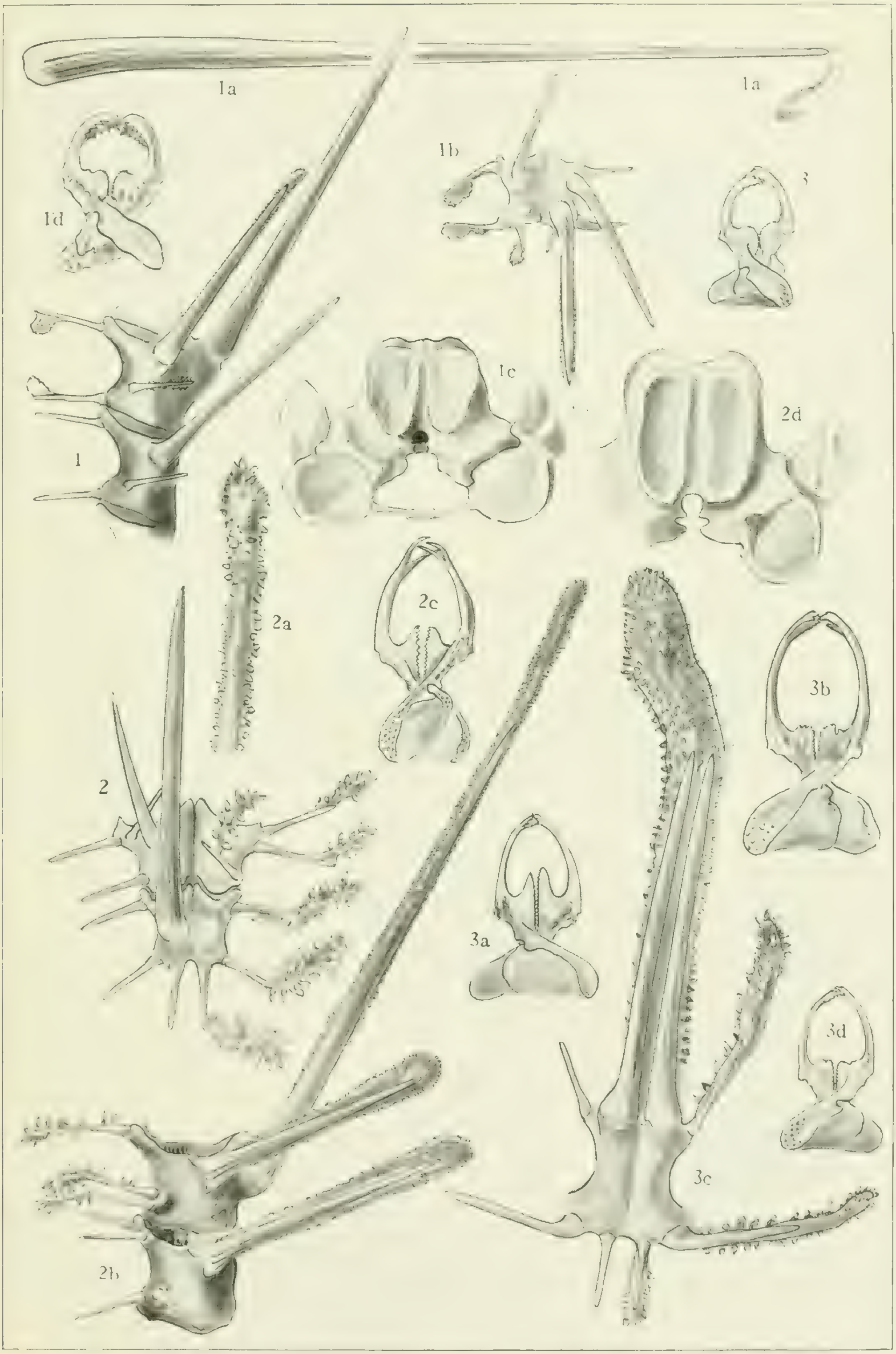
4. *Brisingenes mimica*, type; a pedicellaria from disk (length, 0.45 mm.) × 80. 4*a*. Same; base of the blade of a disk pedicellaria further enlarged. 4*b*. Same; a pedicellaria from a furrow spinelet (length, 0.42 mm.), × 80. 4*c*. Same; end of blade of furrow pedicellaria, enlarged. 4*d*. Same; a pedicellaria from an oral spine at mouth of furrow (length, 0.5 mm.), × 80. 4*e*. Same; adambulacral plates. 4*f*. Same; articulating surface of ambulacral plates of disk, where ray has been broken off. P. 518.

PLATE 153.

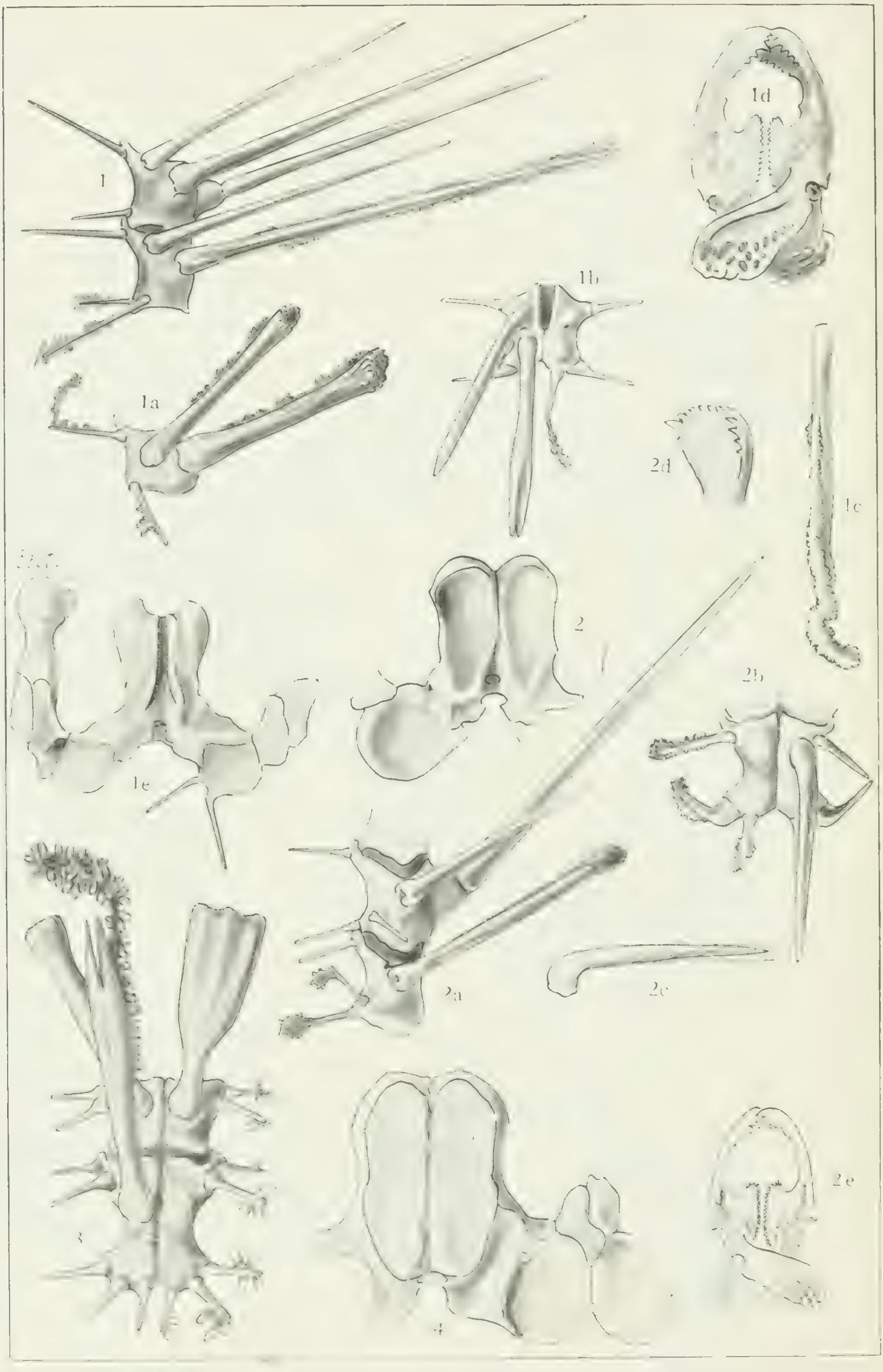
FIG. 1. *Astrostephane acanthogenys*, type; 2 adambulacral plates from the costal area; × 5. 1*a*. Same: a lateral spine, same scale as fig. 1, from the end of the costal area, × 5. 1*b*. Same; mouth plates showing the 2 suboral spines of each; one spine removed from left plate; × 5. 1c. Same: articulating surface of ambulacral and adambulacral plates where ray has been broken from disk; this is the distal face of the plates, × 5. 1*d*. Same; a pedicellaria (length, 0.109 mm.) from one of the furrow spinelets, × 200. P. 528.

2. *Stegnobrisinga placoderma*, type; mouth plates and 2 adjacent adambulacrals, × 5. 2*a*. Same; end of one of the subambulacral spines showing the sheath of pedicellariae, × 5. 2*b*. Same; 2 adambulacral plates from the costal region, × 5. 2*c*. Same; a pedicellaria from a furrow spinelet (length, 0.45 mm.), × 60. 2*d*. Same; articulating surface (distal) of ambulacral and adambulacral plates as seen on periphery of disk after removal of ray, × 5. P. 531.

3. *Brisingenes anchista*, type; pedicellaria from a subambulacral spine (length, 0.22 mm.), × 80. 3*a*. Same; a pedicellaria from disk (length, 0.27 mm.), × 80. 3*b*. Same; pedicellaria from a lateral oral spine (length, 0.40), × 80. 3*c*. Same, station 5648; mouth plates, × 5, showing the common sacculus of the 2 suboral spines. 3*d*. Same; pedicellaria (length, 0.27 mm.) from a furrow spinelet, × 80. P. 521.



Starfishes of the Philippine Seas and Adjacent Waters.



STARFISHES OF THE PHILIPPINE SEAS AND ADJACENT WATERS.

PLATE 154.

FIG. 1. *Craterobrisinga eucoryne;* 2 adambulacral plates from outer third of costal area; the proximal plate with sheath of pedicellariae shown on the 2 proximal furrow spinelets and on the larger subambulacral spine, × 5. 1*a*. Same; fifth adambulacral plate, showing the specialized subambulacral spines, × 5. 1*b*. Same; mouth plates, × 5. 1*c*. Same, a suboral spine from another specimen with the sacculus of pedicellariae, × 5. 1*d*. Same; a pedicellaria (length, 0.21 mm.) from a furrow spinelet, × 160. 1*e*. Same; distal articulating surface of ambulacral and adambulacral plates as seen on periphery a disk after removal of ray, × 5; to the left an interradial plate has been shown (*int.*). P. 514.

2. *Astrostephane moluccana;* same view as 1*e*, without an intermediate plate, × 5. 2*a*. Same; 2 adambulacral plates, middle of costal area, × 5. 2*b*. Same; mouth plates, showing the suboral spine bent toward the actinostome, × 5.6. 2*c*. Same; a suboral spine from the side, × 5.6. 2*d*. Same; tip of pedicellaria (2*e*) showing inside of jaw. 2*e*. Same; a pedicellaria from a furrow spinelet (length, 0.15 mm.), × 160. P. 526.

3. *Freyellaster spatulifer*, type; mouth plates and adjacent pair of adambulacrals, showing variation in the form of the first subambulacral spines and the bifid suboral, × 9.6. P. 538.

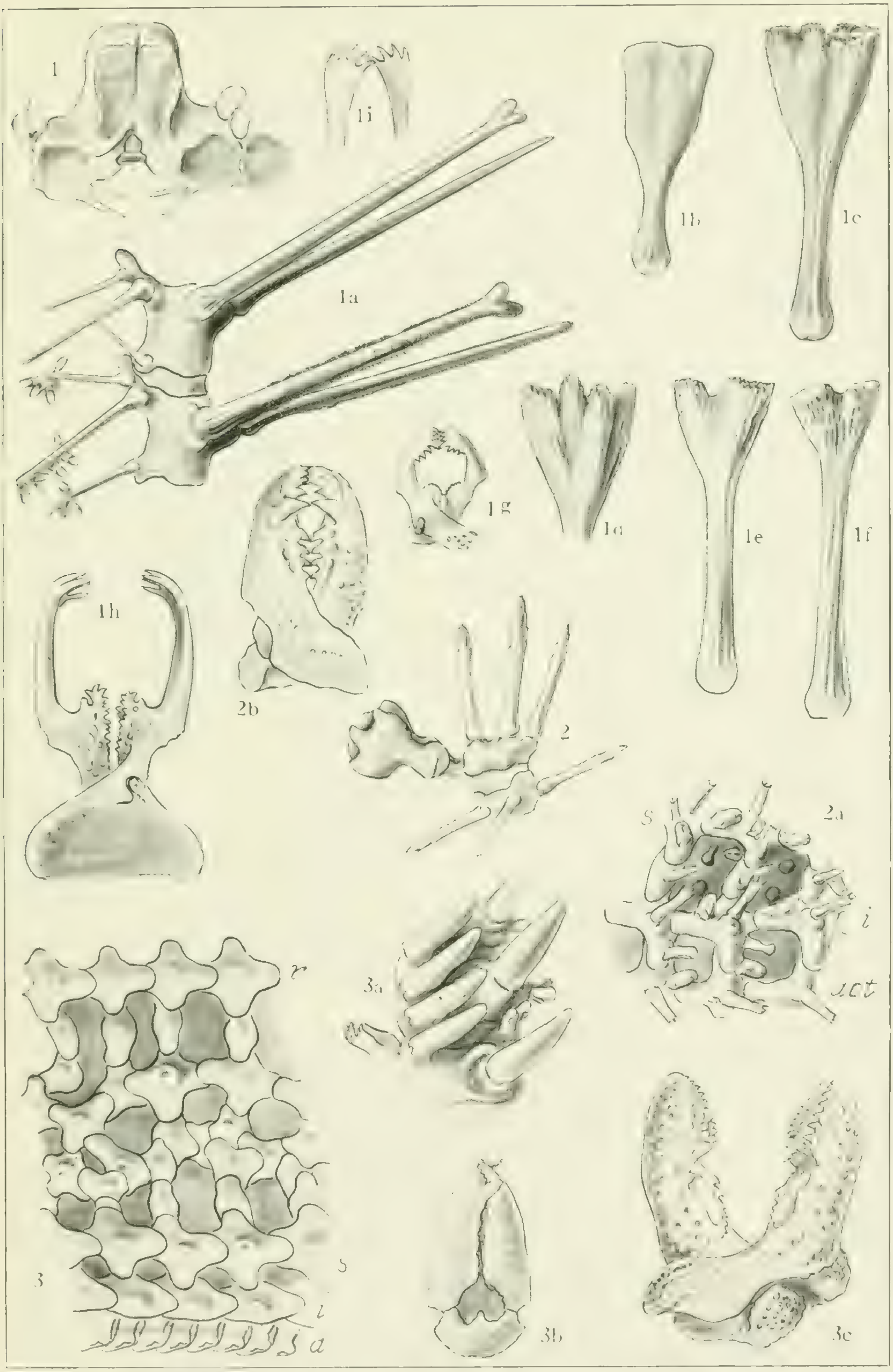
4. *Brisingenes anchista;* distal articulating surface of ambulacral and adambulacral plates as seen on the periphery of disk after removal of ray; on the right 2 adambulacrals of adjacent rays are shown. P. 521.

Plate 155.

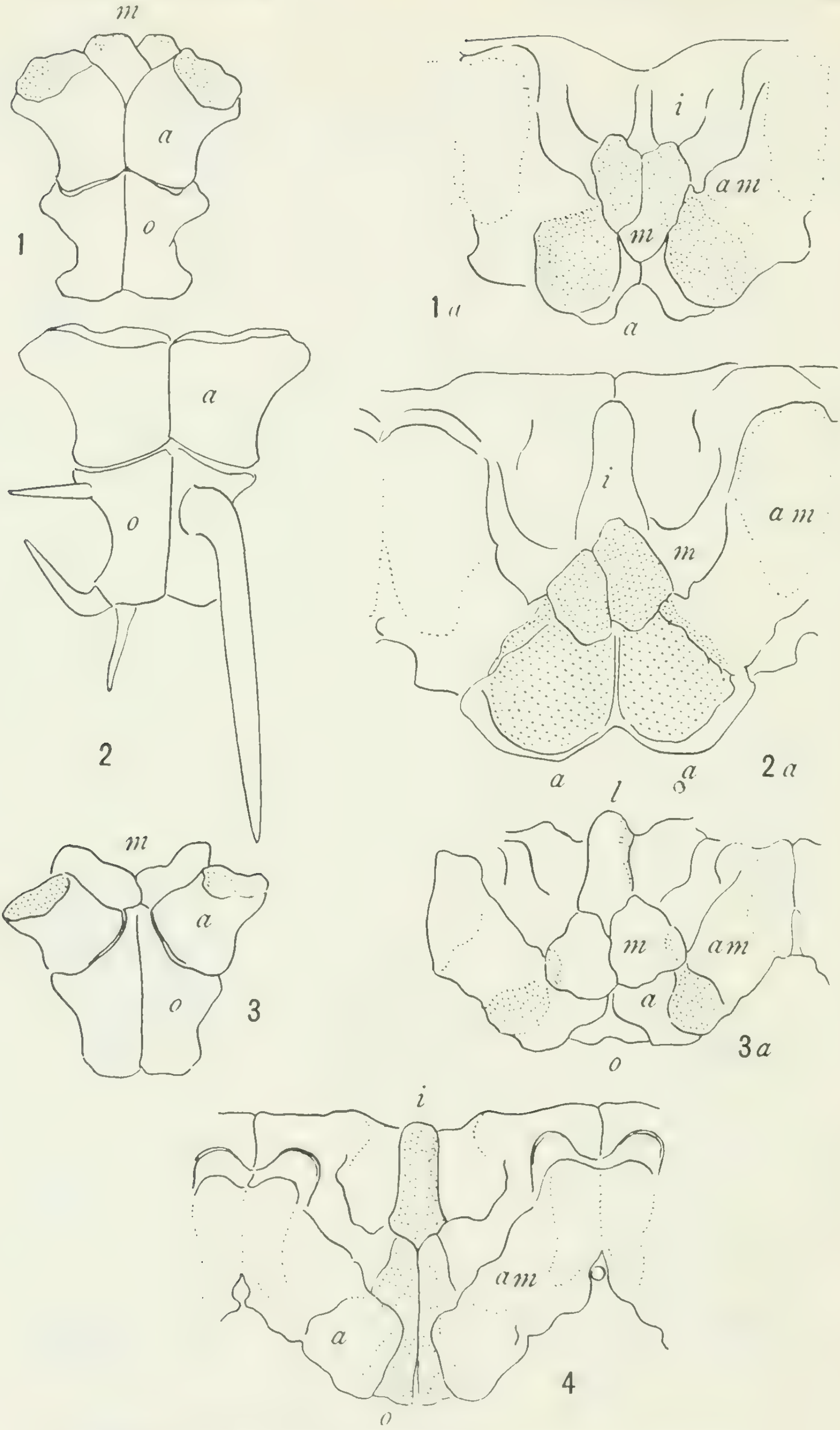
Fig. 1. *Freyellaster spatulifer*, type; distal articulating surface of ambulacral and adambulacral plates, as seen on the periphery of disk after removal of ray; on the right 2 adambulacrals of adjacent rays are shown, × 8. 1*a*. Same; fourteenth and fifteenth adambulacral plates, × 9.6. 1*b*, 1*c*. Same; third and sixth subambulacral spines, × 9.6. 1*d*, 1*e*, 1*f*. Same; end of a sixth, and the ninth and eleventh subambulacral spines, × 9.6. 1*g*. Same; a pedicellaria (length, 0.038 mm.) from a lateral spine, × 400. 1*h*. Same; a pedicellaria from the larger, aboral furrow spine (sixth, 0.33 mm.), × 120. 1*i*. Same; tips of jaws of 1*h*, showing about three-fourths of their breadth. P. 538.

2. *Pedicellaster chirophorus*, type; second and third adambulacral plates, showing the 3 spines which occur on the first few plates of each series (2 on the others) and one of the large "cat-claw" pedicellariae attached to outer end of plate; × 16. 2*a*. Same; a few plates of the side of ray, near base; *s*, superomarginal; *i*, inferomarginal; *act.*, outer series of actinal intermediate plates; × 8. 2*b*. Same; one of the minor pedicellariae enlarged 80 times. P. 499.

3. *Tarsaster distichopus*, type; plates of the ray from the adambulacral (*a*) to midradial series (top) shown as if wall of the ray were spread out flat; *i*, inferomarginal; *s*, superomarginal; *r*, midradial series; the 2 series of dorsolateral plates and connectives are shown between the superomarginals and radials. Taken at about the middle of ray, × 8. 3*a*. Same; adambulacral and inferomarginal armature, at end of the proximal third of ray, × 8. 3*b*. Same; an unguiculate, forficiform pedicellaria from an adambulacral plate, × about 32. 3*c*. Same; one of the forcipiform pedicellariae, × 80. P. 490.



Starfishes of the Philippine Seas and Adjacent Waters.



Starfishes of the Philippine Seas and Adjacent Waters.

PLATE 156.

These figures are intended to show some of the characters upon which several new genera of Brisingidae have been based. See the synopsis, p. 501.

FIG. 1. *Brisinga trachydisca;* actinal view of adambulacral (*a*), marginal (*m*), and mouth (*o*) plates, × 8. 1*a*. Same; lateral view of plates of interbrachial angle after removal of rays; *i*, interradial plate; *am*, ambulacral plate; others as in Fig. 1. P. 510.

2. *Astrostephane moluccana;* actinal view of adambulacral (*a*) and mouth (*o*) plates, × 8. 2*a*. Same; lateral view of plates of interbrachial angle after removal of rays; *i*, interradial plate; *m*, marginal plates; *am*, ambulacral plates; *a*, adambulacral plates. P. 526.

3. *Brisingella fragilis;* actinal view of marginal, adambulacral, and mouth plates, × 8; lettering as in fig. 1. 3*a*. Same; lateral view of plates of interbrachial angle, × 8; only the articular surface of the marginal and adambulacral plates is stippled; side of interradial plate is stippled to show prominence; lettering as in 2*a*. P. 524.

4. *Freyella microplax;* lateral view of plates of interbrachial angle, × 8; lettering as in 2*a*. Only the surface of the interradial and oral plates is stippled; note absence of marginal plates. For description of this species see Fisher, 1917*f*, p. 430.

INDEX.

The following index contains the names of the families, genera, species, and subspecies of Asteroidea which occur in this memoir. Two kinds of type are used for the names, roman and italic; the former indicates valid names, the latter synonyms. But when a species name follows a genus name that is a synonym of another genus name, the species name of the combination is italicized, although the species name may be valid. The heavy-faced type indicates the page upon which the description, or chief citation of the species occurs. The names occurring in the account of the distribution of species, pages 5 to 16, those cited in the list of dredging stations, and those in the explanation of plates have not been indexed.

Page.

- Acanthaster **441**, 406
  - brevispinus **442**, 18, 443
  - *echinites* 4, 5, 441
  - *echinus* 441
  - ellisii 443, 444
  - mauritiensis 18, 442, 443
  - planci **441**, 3, 4, 5, 23, 443
  - solaris 444
- Acanthasteridae **441**, 23
- Anseropoda **424**, 420
  - diaphana 425
  - macropora **424**, 19
  - membranacea 424
  - petaloides 425, 19
  - tenuis 425
- Anthenea flavescens 23
  - spinulosa 3, 4, 23
- *Antheniaster* 328
- Anthenoides 326, 346
  - cristatus **329**, 18, 328, 338, 341
  - epixanthus 21, 329, 333, 338
  - granulosus **333**, 21, 24, 328, 329
  - lithosorus **336**, 328, 329
  - peircei 328, 331, 332
  - rugulosis **338**, 328, 329
  - sarissa 18, 328, 329, 333
- Anthenoidinae 326
- Anthosticte **140**, 2, 22, 90
  - aulophora **140**
- Aphroditaster **225**, 22
  - gracilis 21, 225
  - microceramus **225**, 21, 24
- Archaster 180
  - angulatus **181**
  - *hesperus* 69
  - tenuis 5
  - typicus **180**, 5, 24
- Archasteridae 180, 23
- Asterias 495
- *Asterias discoidea* 360
  - *echinites* 441
  - *echinus* 441
  - *echinophora* 426, 427, 432
  - *endeca* 444
  - *exigua* 416
  - *glacialis* 425
  - *granularis* 257
  - *laevigata* 400

Page.

- *Asterias milleporella* 378
  - *multifora* 400
  - *nodosa* 346
  - *papposa* 447
  - *planci* 441
  - *sagena* 426, 428
  - *sanguinolenta* 428
  - *savignyi* 170
  - *schmideliana* 360
  - *seposita* 426, 427, 428
  - *spinosa* 426, 432
  - *stichantha* 487
  - *tenuispina* 24
  - *volsellata* 4, 5, 494, 496
- Asteriidae **487**, 23
- Asterina **409**, 216, 410, 419
  - burtonii 411
  - cepheus **411**, 3, 5, 24
  - *cristata* 411
  - *cristata euerces* 414
  - coronata 24
  - coronata coronata 414
  - coronata cristata **411**, 2, 19, 410, 414, 416
  - coronata euerces **414**, 19, 410, 413
  - coronata fascicularis 414
  - *gibbosa* 4
  - *pentagona* 4
- Asterinidae **409**, 23
- *Asterinides* 410
  - *cepheus* 410
  - *folium* 410
  - *minuta* 410
  - *modesta* 410
  - *wega* 410
- Asterinopsis **417**, 2, 410, 419
  - lymani 410
  - pedicellaris **417**
  - penicillaris 410, 419
  - pilosa 410
- *Asteriscus cepheus* 411
- Asterope 405, 407
  - carinifera 4, 24
- Asteropidae 407
- *Asteropsis* 405
- Asterodiscus **354**
  - elegans **355**, 5, 354, 360
  - helonotus **357**, 19, 355
  - truncatus 19, 355, 357, 358, 359

Page.
Asterodiscus tuberculosus.............. 355, 356, 360
Asthenactis.............................. 455, 456
medusa.............................. 454
papyraceus.......................... 454
Astroceramus......................... **309**, 22, 304
callimorphus......... 19, 310, 311, 312
fisheri.......................... 316
lionotus......................... 310, 19
sphaeriostictus....... **313**, 19, 307, 310
Astrocles.......................... 504
actinodetus...................... 504
Astrogonium jordani...................... 220
longimanum.............. 262, 303, 305
Astrolirus........................ 504, 525, 530
Astromesites...................... **107**, 2, 22, 90
compactus........................ **107**
Astropecten........................ **62**, 2
acanthifer............. 18, 24, 65, 66, 73
acanthifer phragmorus........... 65
alatus............................ 24
andersoni.................. 17, 24, 67
astropectinides..................... 91
bandanus........................ 24
bengalensis...................... 70
bonnieri......................... 79
celebensis....................... 24
debilis.......................... 68
cremicus................ **79**, 18, 62, 82
eucnemis................ **75**, 18, 62, 79
granulatus.......... **73**, 18, 62, 77, 78, 79
griegi.................... 7, 82, 84, 89
hawaiiensis..................... 73
hemprichii..................... 70, 72
imbellis..................... 4, 23, 36
indicus.......................... 79
koehleri......................... 73
ludwigi...................... 90, 91
luzonicus...................... **82**, 62
macer........................... 60
malayanus........................ 79
mauritiensis..................... 73
mauritiensis..................... 70
mindanensis............... **67**, 17, 62
monacanthus........... **74**, 4, 62, 78, 79
notograptus...................... 79
orientalis....................... 79
orsinii.......................... 73
pedicellaris.............. **87**, 17, 62
phragmorus................ **65**, 18, 62
polyacanthus............. **63**, 5, 24, 62
[illegible]...................... 73
pusillus......................... 79
[illegible]...................... 18, 82
sarisinorum...................... 79
scoparius........................ 73
tenellus.............. **84**, 17, 62, 82, 87
[illegible]...................... 24
triseriatus...................... 73
umbrinus......................... 79
vappa........................ 70, 73
vappa inaequalis.............. 69, 62
[illegible]............... 70, 24, [illegible], 72
velitaris................... 73, 78
zebra........................ 77, 78
zebra sibogae.................... 24
Astropectinidae..................... 59, 23, 156
Astrostephane.................. 525, 2, 23, 503, 509
acanthogenys... 528, 525, 526, 534, 535
moluccana.......... 526, 24, 525, 535
Astrothauma.......................... 320, 2, 22
euphylacteum................. 320
Atelorias............................ 342, 2, 22
anacanthus....................... 343, 24
Bathybiaster......................... 99, 110
Belgicella........................... 504
racovitzana.................. 504
Benthogenia.......................... 39, 2, 22
cribellosa................... 39
Benthopecten......................... 208
acanthonotus................ 208
antarcticus.................. 210
huddlestonii............. 21, 208, 210
moluccanus............... 208, 21, 24
mutabilis.................... 211
polyctenius... 211, 21, 24, 208, 213, 215
semisquamatus............... 210
spinosus................. 208, 211
styracius............ 213, 21, 24, 208
violaceus....... 21, 211, 212, 213, 215
Benthopectinidae....................... 182, 23
Blakiaster................... 90, 99, 107, 110
Brisinga............... 509, 2, 492, 493, 501, 502, 503,
512, 518, 523, 525, 530, 533, 537
acanthogenys...................... 528
andamanica.............. 18, 512, 534
bengalensis................. 520, 534
coronata.................... 509, 534
endecacnemos....... 503, 509, 518, 523, 524
eucoryne........................ 514
fragilis................ 503, 523, 524
gracilis...................... 533
gunnii....................... 512, 534
insularum.................... 520, 534
mimica.................. 501, 517, 518
moluccana............... 503, 525, 526
[illegible]................ 504, 530
panopla.................... 503, 512
placoderma.............. 503, 530, 531
semicoronata................ 501, 505
trachydisca....... **510**, 18, 509, 518, 520, 533
Brisingaster........................... 502
robillardi..................... 502
Brisingella........... 523, 2, 22, 502, 503, 509, 513, 525
armillata................... 524, 535
coronata.................... 509, 524
discincta...................... 524
exilis......................... 524
fragilis................ 524, 525, 535
pusilla........................ 524
mediterranea................... 524
membranacea................... 524
tenella........................ 524
verticillata................... 524
Brisingenes................... 517, 2, 22, 501, 525
anchista........... 521, 24, 518, 520, 535
mimica................. 518, 24, 534
Brisingidae 501, 23, 492, 493, 494
Bunaster.............................. 398
lithodes................... 398, 2, 18
ritteri................. 18, 24, 398, 399
Bythiolophus.................... 484, 2, 471, 481
acanthinus................... 485, 25

Page.
Calliaster........................ 316, 320, 323, 324
 baccatus...................... 317, 319
 childreni...................... 316, 319
 corynetes...................... 316, 1
 mamillifera...................... 319
 pedicellaris................ 19, 317, 319
[illegible]...................... 12[illegible]
Carna...................... 424
Ca[illegible]...................... 409
Ceramaster................ 257, 226, 243, 253, 297
 arcticus...................... 260
 clarki...................... 19, 257
 granularis...................... 287
 smithi...................... 257, 19
Chaetaster moorei......................
Cheiraster...................... 190
 diomedeae................ 200, 19, 191
 gazellae,......... 196, 19, 190, 191, 201, 203
 granulatus...................... 207
 inops.................. 191, 18, 19, 201
 ludwigi.................. 203, 21, 191
 niasicus....... 192, 18, 19, 25, 190, 191, 201
 pilosus.................. 18, 194, 195
 snyderi............... 19, 197, 198, 201
 subtuberculatus 21, 205, 207
 triplacanthus............ 205, 21, 25, 191
 trullipes............... 21, 23, 195, 205
Chione...................... 388
Chondraster...................... 407
Choriaster...................... 367
 granulatus.................. 367, 5, 25
Circeaster...................... 297
Cnemidaster.................. 480, 471, 481, 485
 squameus...................... 18, 481
 wyvillii...................... 480, 18, 25
 zea.................. 18, 481, 483
Colpaster...................... 504
 scutigerulus...................... 504
Coronaster.................. 494, 491, 492, 493
 antonii...................... 494, 495
 bispinosus...................... 494
 briareus...................... 494
 halicepus............ 497, 25, 495, 496
 octoradiatus...................... 494
 parfaiti...................... 494, 495
 volsellatus............ 496, 494, 495
Coscinasterias...................... 495
 euplecta...................... 487
Craspidaster...................... 60
 hesperus...................... 60, 4
Craspidasterinae...................... 59
Craterobrisinga............ 512, 2, 23, 503, 525
 alberti...... 19, 513, 514, 516, 525, 536
 analoga............ 516, 513, 536
 cricophora...................... 513
 eucoryne... 514, 19, 513, 516, 517, 536
 evermanni..... 513, 528, 534, 535, 536
 multicostata...................... 513
 [illegible]............ 513, 517, 5[illegible]
 parallela............ 513, 517, 536
 variispina...................... 513
Crenaster...................... 160
 mollis...................... 160
 spinulosus...................... 160
Cribrella densispina...................... 436
Crossaster...................... 447
 japonicus...................... 21, 449
Crossaster papposus...................... 447, 449
 penicillatus...................... 21, 449
 scotophilus.................. 477, 21, 25
Ctenodiscus.................. 44, 22, 18, [illegible]
 crispatus...................... 18, 44
 orientalis...................... 44, 18, 25
Ctenodiscinae...................... [illegible]
Ctenophoraster...................... 95, 22, 90
 diploctenius...................... 95, 18
 hawaiiensis......... 18, 95, 96, 97, 98
Ctenopleura...................... 90, 2, 22
 astropectinides...................... 91
 ludwigi...................... 91
Culcita...................... 360, 362, 366
 arenosa...................... 25, 361
 coriacea...................... 366
 discoidea...................... 25
 grex...................... 25
 novae-guineae............ 380, 5, 25, 363, 366
 novae-guineae plana.............. 361, 25
 plana...................... 25
 schmideliana.............. 25, 363, 366
 veneris...................... 366
Culcitaster...................... 362
 anamesus...................... 362
Cycethra...................... 215
Dendrogaster...................... 37
Diplopteraster...................... 462, 470
 multipes.................. 21, 22, 462
 multipes patagiatus...... 462, 21, 25
 peregrinator 463
 verrucosus...................... 463
Dipsacaster.................. 145, 90, 141, 156
 diaphorus.................. 152, 145, 156
 grandissimus............ 147, 148, 149
 imperialis.................. 146, 18, 145
 laetmophilus.................. 151, 148
 magnificus...................... 150
 nesiotes.......... 145, 18, 25, 145, 148
 pentagonalis...................... 150
 sladeni.......... 18, 145, 146, 151, 152
Dissogenes...................... 267, 2, 22
 styracia...................... 368, 25
Distolasterias...................... 487
 dubia...................... 489
 euplecta...................... 487, 489
 eustyla...................... 489
 hypacantha...................... 487, 18
 mazophora...................... 18, 489
 mollis...................... 489
Dorigona...................... 261, 262
 confinis...................... 247
 longimana...................... 304, 305
 pentaphylla...................... 301
 reevesii...................... 262, 304, 305
 ternalis...................... 262
Dytaster...................... 157, 160
 aequivocus...................... 160
 [illegible]...................... 133
 evaulus...................... 157
 exilis...................... 161
 gilberti...................... 160
 grandis...................... 160
 inermis...................... 4, 23, 25
 madreporifer...................... 160
 nobilis...................... 160
 spinosus...................... 160

Page.
Echinaster **426**, 427
  acanthodes 432
  braziliensis 427
  callosus **428**, 25, 432, 433
  crassus 427
  echinulatus 26
  [illegible] 25, 427
  eschrichtii 427
  fallax 3, 4, 27, 427
  gracilis 427
  oculatus 427
  purpureus 5, 25
  sagenus 428, 432
  sepositus 427
  serpentarius 427
  solaris 3, 4, 427
  spinosus 427
  spongiosus 427
  stereosomus **430**, 433
Echinasteridae **426**, 23
Enoplopatiria 410
  braziliensis 410
  marginata 410
  [illegible] 410
  stellifera 410
Eugoniaster 217
Ferdina 370
  flavescens 370
  glyptodisca **370**, 21, 25
  offreti 21, 370, 371, 372
Flabellum 333
Freyella 2, 492, 502, 504, 539, 533, 537, 538
  benthophila 538
  bracteata 538
  dimorpha 538
  echinata 4, 23, 540
  elegans 538
  fecunda 504, 537
  fragillisima 538
  heroina 538
  insignis 538
  microplax 538
  pacifica 538
  polycnema 538
  propinqua 538
  remex 538
  sexradiata 538
  spatulifera 25, 538
  spinosa 504, 537, 538
  tuberculata 538
Freyellaster **537**, 2, 22, 502, 504, 530
  fecundus 538
  spatulifer 538
  scalaris 538, 540
Freyellidea 537
Fromia 373
  andamanensis 377
  armata 18, 377, 378
  baiansae 377, 378
  cancellata 373
  eusticha **375**, 373
  hemiopia **377**, 18, 373
  japonica 373
  kuhlii 373
  major 373, 374
  milleporella **378**, 5, 25, 373, 375, 377
  monilis 25, 374
Ganeria 216
  falklandica 216
Ganeriidae **401**, 23
Gastraster 494
Gephyreaster 216
Glyphodiscus **306**, 2
Goniaster cuspidatus 25
  nidarosiensis 290
Goniasteridae **220**
Goniasterinae **240**
Goniodiscaster **224**
  forficulatus **324**
  pleyadella 25
Goniodiscides 362
Goniodiscus 362
  capella 305
  forficulatus 324
  pleyadella 324
  rugosus 5
  sebae 361
Goniopecten **46**, 22, 44, 46, 47, 236
  asiaticus **47**, 50, 55, 57, 59
  demonstrans 47, 50
Goniopectinidae **43**
Goniopectininae **46**
Gymnasteria carinifera 4, 25
Gymnobrisinga 502
  sarsii 502
Halityle **362**, 2, 22
  regularis 362
Henricia 435
  arcystata **439**, 18, 435, 436
  densispina **436**, 435
  leviuscula annectens 436
  leviuscula multispina 436
  microplax **437**
  mutans 18, 435, 439, 440
  oculata 435
  praestans 439, 440
  sanguinolenta 428, 435, 437
Heterasterias 494
  volsellata 496
Hippasteria 294, 331
Hosia spinulosa 3
Hydrasterias ophidion 491
Hymenaster **463**, 467, 470
  bartschi **465**, 19
  koehleri 21
  nobilis 21, 463, 464, 465
  pellucidus 463
  pullatus 19, 465, 467
  rhodopeplus 463, 21, 25, 464, 465
Hymenasteridae **467**, 2, 22
  zenognathus **468**, 25
Hymenodiscus 502
  agassizi 502
Hyphalaster 42
  hyalinus 42
Iconaster **303**, 2, 298, 309
  gardineri 269, 309
  longimanus 303, 306
  pericretus **306**
Koremaster **157**, 2, 22
  evaulus **157**, 18, 26
  evaulus spiculatus **161**, 18
Labidiaster 492, 493, 494
  annulatus 493

Page.

- Labidiaster radiosus 492, 493
- Labidiasterinae 492, 494
- Labidiastrella 493
- *Lasiaster villosus* 407
- Leiaster 396
  - analogus 396, 18
  - callipeplus 398
  - coriaceus 18, 396, 397, 398
  - glaber 398
  - leachii 5, 26, 396, 397, 398
- *Leptogonaster* 331
  - *cristatus* 4, 328, 329
- *Leptogonasterinae* 326
- Leptychaster 90, 99, 107, 110, 216
- Linckia 400, 396
  - *diplax* 401
  - dubiosus 394
  - ehrenbergii 401
  - guildingii **401**, 26, 400
  - laevigata **400**, 3, 4, 5, 26
  - *megaloplax* 388, 390
  - *miliaris* 3, 4, 5
  - multifora 400
  - pacifica 401
  - *pusilla* 3
  - rosenbergi 26
  - *tuberculata* 26
  - *typus* 400
- Linckiidae 367, 23
- Lithosoma 298, 2, 22, 309
  - actinometra 298, 2
  - penichra 301, 298
  - pentaphylla 18
- Lonchotaster forcipifer 151
  - *magnificus* 150
  - tartareus 151
- Lophaster 449
  - abbreviatus 450
  - antarticus 450
  - furcifer 19, 450
  - furcilliger 449
  - gaini 450, 451
  - stellans 450
  - suluensis 449, 19
- Luidia 163
  - africana 166, 168
  - aspera **171**, 4, 5, 163
  - asthenosoma 18, 166, 167, 168
  - avicularia **172**, 18, 163
  - *chefuensis* 166
  - ciliaris 163
  - clathrata 166
  - denudata 18, 175, 176, 177, 178
  - elegans 168
  - foliolata 166
  - forficifera 5, 18, 164, 165, 166
  - *fragilissima* 163
  - gymnochora **175**, 163
  - hardwickii 5
  - integra 18, 172, 174
  - *limbata* 166
  - longispina **164**, 4, 5, 163
  - maculata **168**, 4, 5, 26, 163
  - moroisoana 18, 172, 174, 175
  - orientalis **166**, 18, 163
  - penangensis 166
  - prionota **164**, 18, 163
- Luidia quinaria 166
  - sarsi 166, 168
  - savignyi **170**, 163
- Luidiaster dawsoni 199
- Luidiidae 163, 23
- Lydiaster 297
- Lysaster 43
- Mammaster 471, 481
- Marginaster 407, 22
  - capreensis 407, 409
  - echinulatus 409
  - *fimbriatus* 407, 409
  - paucispinus 407
  - pectinatus 407
  - pentagonus 409
- Mediaster 255, 243, 253, 261
  - aequalis 255
  - arcuatus 255
  - bairdii 255
  - ornatus 256, 255
  - tenellus 242
- *Melia* 378
- Metrodira 405, 370
  - subulata 406, 3, 26, 405
- Metrodiridae 405, 23
- *Metrodirinae* 405
- Milteliphaster 323, 324
- *Mimaster* 22
  - *cognatus* 215
  - *notabilis* 215, 217
  - *tizardi* 215, 217
- *Mimasteridae* 215
- *Mimasterinae* 215
- Mimastrella 217
- Mithrodia clavigera 5, 26
- Moiraster 90, 143, 144
- Myxaster 454, 22, 456
  - medusa 454, 21, 26
  - sol 21, 454, 455
- Myxasteridae 454, 23
- Myxoderma 471
- Narcissia 370, 384
- Nardoa 378
  - aegyptiaca 379, 380, 382, 384
  - *finschi* 379, 381
  - frianti 385, 18, 379, 382, 384, 386
  - galatheae 26, 382
  - *gomophia* 379, 380, 384
  - lemonnieri 382, 380, 384
  - mollis 381, 382, 383
  - novae-caledoniae 23, 379, 380, 381, 382
  - obtusa 4, 23, 379, 385, 387
  - pauciforis 23, 379, 381
  - semi regularis 383, 23, 375, 379, 384
  - semiseriata 384
  - squamulosa 383, 380, 384
  - tuberculata 384, 3, 4, 5, 23, 382, 384
  - tumulosa 386, 18, 379, 382
  - variolata 378, 379, 387
- Nectria 212, 255
  - ocellifera 26
  - ocellata 256
- Nepanthia 422, 2, 402, 419
  - *brachiata* 419
  - brevis 423, 424
  - joubini 423, 422
  - maculata 422, 3, 413, 419, 423

Page.

- Nepanthia *pedicellaris* 417
  - *platydisca* 420
  - suffarcinata 423
- *Nereidaster* 240, 261
  - *bowersi* 241
  - *symbolicus* 253
- Nymphaster 261, 243, 244, 253, 294, 301, 303, 309
  - albidus 261
  - arenatus 277
  - arthrocnemis 277, 18, 26, 264
  - atopus 285, 263
  - belli 18, 266, 272, 274, 282
  - basilicus 261
  - *bipunctus* 261
  - diomedeae 266
  - dyscritus 266, 18, 263, 309
  - euryplax 264, 18, 263
  - florifer 242
  - gardineri 18, 269
  - habrotatus 282, 264
  - leptodomus 272, 263
  - ludwigi 21, 266, 276, 281, 282
  - meseres 280, 18, 264
  - moluccanus 274, 21, 26, 263
  - mucronatus 269, 18, 263
  - nora 280
  - protentus 253, 261
  - *symbolicus* 4, 240, 253, 261
  - ternalis 18, 266, 276, 278, 282
- Odinia 505, 492, 495, 501
  - austini 506, 509
  - clarki 506, 509
  - magister 507
  - pacifica 506, 507, 509
  - penichra 505
- Ogmaster 305, 330
  - capella 262
- Ophidiaster 388
  - cylindricus 26, 392
  - dubiosus 394, 388
  - fuscus 388, 3, 26
  - germani 391
  - hirsutus 388, 390
  - ophidianus 388
  - ornatus 382, 394
  - purpureus 26, 392
  - pusillus 3, 4, 23, 26, 390, 392, 393
  - pustulatus 26, 392, 396
  - rhabdotus 396
  - sclerodermus 394, 395, 396
  - squameus 392
  - tenellus 394, 396
  - triseriatus 393
  - trychnus 390, 385, 392
  - tuberculatus 384
  - tuberifer 393, 388, 390, 392
  - tumescens 396
- Ophidiasteridae 367
- Oreaster 346, 354, 362
  - affinis 26
  - alveolatus 348, 346, 354
  - grayi 26
  - hawaiiensis 354
  - hiulcus 26
  - linckii 27, 349
  - mammillatus 354
  - nodosus 346, 5, 27

Page.

- Oreaster novae-caledoniae 349
  - occidentalis 354
  - productus tuberatus 23
  - rheinhardti 26
  - sladeni 26
- Oreasteridae 346, 23
- Othilia 432, 426
  - *eridanella* 27, 434, 435
  - *luzonica* .... 3, [illegible]
  - purpurea 432, 3, 4, 435
- Paragonaster 228, 244
  - ctenipes 18, 228
  - ctenipes hypacanthus 228, 18
  - elongatus 235
  - formosus 235
  - stenostichus 232, 228
  - strictus 235
  - subtilus 235
- Paranepanthia 419, 2, 22, 417
  - platydisca 420, 27
- *Pararchaster* 208, 213
  - *pedicifer* 208
- Parasterina 419
- Patagiaster 154, 22, 90
  - nuttingi 18, 154
  - sphaerioplax 154, 18
- Patiria 410
  - *briareus* 5
  - chilensis 410
  - coccinea 410
  - gayi 410
  - granifera 410
  - granulata 410
  - miniata 410
  - novae-zelandiae 410
  - pectinifera 410
- Patiriella 416, 410
  - calcar 410
  - calcarata 410
  - exigua 416, 4, 27, 410
  - fimbriata 410
  - gunnii 410
  - pusilla 410
  - regularis 410
  - squamata 410
- Pectinaster 182, 189
  - evoplus 185, 189
  - filholi 189
  - forcipatus echinatus 182, 184, 185
  - hispidus 182, 183
  - hylacanthus 187, 27, 182, 194, 196
  - mimicus 182, 18, 27, 187
  - mimicus palawanensis 165, 18, 182
- Pectinidiscus 41, 236
- Pedicellaster 499, 492, 493, 495, 501
  - chirophorus 499, 27
  - typicus 499
- Pedicellasteridae 492, 23
- Pedicellasterinae 499, 494
- Peltaster 290, 22
  - cycloplax 290
  - [illegible] 290
  - nidarosiensis 290, 293, 294
  - planus 294
- Pentaceropsis 350, 347
  - *euphues* 354
  - obtusata 4, 5, 18, 23, 27, 350, 353

Page.

- Pentaceropsis tyloderma………… 350, 18
- *Pentaceros*………… 346
  - *alveolatus*………… 348
  - *franklinii*………… 346
  - *modestus*………… 346
  - *obtusatus*………… 4
  - *productus tuberatus*………… 4
  - *turritus*………… 5, 346
- *Pentacerotidae*………… 346
- *Pentagonaster*………… 324
  - *alexandri*………… 240, 261
  - *arenatus*………… 262
  - *cuenoti*………… 260
  - *mirabilis*………… 260
  - *mortenseni*………… 260
  - *mülleri*………… 262
  - *placenta*………… 260
  - *spinulosus*………… 4
  - *subspinosus*………… 262
- Perissogonaster………… **235**, 2, 22
  - insignis………… **236**, 235
- Persephonaster………… **111**, 90, 107
  - anchistus………… **117**, 18, 111, 127, 130
  - cingulatus………… 21, 23, 124
  - coelochiles………… 18, 115
  - croceus………… 21, 111, 134, 136
  - euryactis………… **112**, 17, 111, 130
  - euryactis brevispinus………… **115**
  - gracilis………… 133
  - habrogenys………… **131**, 112, 134
  - luzonicus………… **118**, 111, 127, 130
  - misakiensis………… 18
  - monostoechus………… **134**, 18, 27, 111, 136
  - multicinctus………… **123**, 18, 21, 27, 111, 125, 126, 127, 130, 136
  - oediplax………… **127**, 112, 130, 131, 133
  - patagiatus………… 124
  - roulei………… 21, 121, 124
  - suluensis………… **125**, 18, 111, 130
  - tenuis………… **121**, 111, 130
- *Philiaster*………… 100
  - *agassizi*………… 100
- Pholidaster………… **484**, 471, 485
  - distinctus………… 18
  - squamatus………… **484**, 4, 18
- Plinthaster………… 294
- Plutonaster………… 90
- *Pontaster mimicus*………… 182
  - *trullipes*………… 4
- Pontioceramus………… **294**, 2, 22
  - grandis………… 294
- Porania………… 407
  - *grandis*………… 407
  - pulvillus………… 407
- Poraniella………… 407
- Poraniidae………… **407**, 23
- Poraniomorpha………… 407
  - rosea………… 407
- Poranisca………… 407
- Porcellanasteridae………… 35, 23
- Priamaster………… 216
- Priamasterinae………… 216
- Prionaster………… **50**, 22, 44, 47, 236
  - analogus………… **50**, 21, 55, 56, 57
  - elegans………… 44, 50, 54
  - gracilis………… **55**, 41, 50, 57
  - megaloplax………… **56**, 21, 27, 44, 50

Page.

- Prognaster………… 470
  - grimaldii………… 470
  - *longicaudus*………… 470
- Pseudarchaster………… 220, 156
  - dissonus………… 21, 225
  - jordani………… 220, 27
  - mozaicus………… 221
  - myobrachius………… 225
  - oligoporus………… 222, 21, 27
  - pectinifer………… 21, 222
  - roseus………… 225
  - tessellatus………… 225
- Pseudarchasterinae………… 220
- Psilaster………… 100, 107
  - agassizi………… 17, 101, 103, 104, 105
  - florae………… 106
  - gotoi………… 100, 17, 18, 21
  - *gracilis*………… 123
  - pectinatus………… 106
  - robustus………… 103, 17, 18, 21, 27
- *Psilasteropsis cingulata*………… 111
- Pteraster………… **456**, 470
  - *capensis*………… 460
  - corynetes………… **456**, 21, 27
  - *cribrosus*………… 4
  - ingolfi………… 458
  - militaris………… 456
  - *multipes*………… 462
  - obesus………… 19, 458, 460
  - obesus myonotus………… **458**, 19
  - personatus………… 458
  - pulvillus………… 456, 458
  - reductus………… 458
  - rugatus………… 457, 458
  - semireticulatus………… 21, 456, 458
  - sordidus………… 458
  - temnochiton………… 457, 458
- Pterasteridae………… **456**, 23
- Pycnopodia………… 493
- Pythonaster………… 456
- Radiaster………… 217, 22, 216
  - elegans………… 21, 216
  - notabilis………… **217**, 21, 27, 216
  - tizardi………… 21, 216
- Radiasteridae………… **215**, 23
- Radiasterinae………… 216
- *Randasia*………… 362
  - *luzonica*………… 3
- Rathbunaster………… 493
  - californicus………… 493
- Retaster………… 460
  - cribrosus………… 460
  - insignis………… **460**, 4, 27
- *Rhegaster*………… 407
- Rhipidaster………… 451, 453
  - *polyctenius*………… 451
  - vannipes………… 5, 451, 452, 453
- *Rhopia*………… 426, 427
  - *mediterranea*………… 428
  - *seposita*………… **426**, 428
- Ripaster………… 90
- Rosaster………… **240**, 243, 261
  - alexandri………… 240, 241, 243, 247, 255
  - bipunctus………… **242**, 244, 250, 253
  - confinis………… 18, 241, 243, 244
  - mamillatus………… **217**, 244
  - mimicus………… **250**, 243, 255

Page.

- Rosaster nannus **244**, 18, 241, 243, 253, 255
  - symbolicus **253**, 241, 244, 250, 255, 261
- *Scaphaster* 405
  - *humberti* 405, 406
- *Scytaster obtusus* 4
  - *tuberculatus* 4, 384
- Sidonaster 35, 22
  - batheri 35
  - psilonotus 37
  - vaneyi 35, 22
- Solaster **444**, 216, 218
  - abyssorum 447
  - borealis 445, 446, 447
  - endeca 447
  - *furcifer* 449
  - paxillatus 21, 445, 446
  - regularis 446
  - *scotophilus* 447
  - subarcuatus 447
  - torulatus 446
  - tropicus **444**, 21, 27, 446
  - *tumidus* 407
- Solasteridae **444**, 23
- Sphaeriodiscus 287, 260
  - ammophilus 288, 290
  - bourgeti 288, 290
  - scotocryptus 287
- Stegnobrisinga **530**, 2, 23, 502, 509, 513, 525
  - gracilis 535, 536
  - placoderma **531**, 27, 520, 522, 536
- Stellaster 326, 346
  - *belcheri* 27, 326
  - childreni 326
  - equestris 327
  - incei 326, 5, 27

Page.

- Stellaster gracilis 326
  - *sulcatus* 60
- *Stephanaster bourgeti* 287
- *Stolasterias* 494
- *Tamaria fusca* 3, 388
- Tarachaster **401**
  - tenuis **402**
- Tarsaster **490**, 2
  - distichopus **490**, 21, 27
  - stoichodes 21, 490, 491
- Tethyaster 90, 143, 144
  - subinermis 141
- Thoracaster 42
- Thrissacanthias 90
- Tritonaster **136**, 22, 90
  - craspedotus 18, 136, 137, 138, 139
  - evorus **136**, 18
- Tylaster 407
- *Undina* 400
- Valvaster 406
- Xenorias **451**, 2, 22
  - polyctenius **451**, 27
- Zoroaster **471**, 484, 485
  - adami 18, 472, 475
  - angulatus 472, 477
  - barathri 21, 473, 475
  - carinatus 18, 472, 477, 479
  - carinatus philippinensis **477**, 18, 472
  - fulgens 471
  - microporus **475**, 21, 27, 472, 473
  - ophiactis **473**, 18, 27, 471, 472, 475
  - planus 472, 477
  - spinulosus 472
  - tenuis 472
- Zoroasteridae **470**, 23

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 01421 1593